SHORTAGE OF SCIENTIFIC AND ENGINEERING MANPOWER

HEARINGS

BEFORE THE

SUBCOMMITTEE ON RESEARCH AND DEVELOPMENT

OF THE

JOINT COMMITTEE ON ATOMIC ENERGY

CONGRESS OF THE UNITED STATES

EIGHTY-FOURTH CONGRESS

SECOND SESSION

ON

SHORTAGE OF SCIENTIFIC AND ENGINEERING MANPOWER

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PREFACE

The testimony on the following pages regarding present and future shortages of technically trained manpower in this country, which was presented to the Joint Committee's Research and Development Subcommittee earlier this year, is a shocking indictment of America's indifference toward one of the most serious problems facing this Nation and paints a graphic picture of what America stands to lose in future years if we do not immediately initiate vigorous corrective measures. It is the hope of the Joint Committee that this testimony will be widely read by the American people so that they may gain a better appreciation of the urgency of making a start in this direction now.

The basic issue is whether or not we as a Nation are willing to sit by and watch Soviet Russia, with her vast technical training programs, outstrip us in technological development in the coming years, or whether we take action now to see to it that the United States has the trained manpower to insure our continued world leadership in this field. We are in a battle for brainpower. Are we to lose it by default?

But even without the Russian threat, can we in all good conscience stand idly by and jeopardize the rapid development of our technological resources which are so essential to our Nation's well-being? I think the answer is obvious to all who have given this matter serious thought.

It has become apparent to the Research and Development Subcommittee, as it has delved progressively deeper into the manpower problem, that there are no easy solutions, no pat answers to fall back on. It has also become apparent that the shortage of scientific and engineering talent is only part of a much larger national problem of identifying and developing our best young minds in this country so as to realize maximum advantage from our potential intellectual resources. It is the development of this brainpower and the upgrading of our educational system so as to make it more attuned to the needs of our economy which is at once the most challenging and most important job we have to do.

Although this committee is concerned primarily with the needs of the atomic energy program and with providing the necessary manpower to insure rapid progress of this program, it has become increasingly obvious that in the long run an adequate number of trained technicians for atomic energy can best be achieved, and maintained, by increasing our overall supply of specialized talent in all fields of endeavor. This is not to say that short-term measures to remedy critical deficiencies in a particular area are not desirable or necessary, but it is important that such measures be made an integral part of a long-range program so as not to create imbalances which could undermine the very strength we are trying to build up.

It is vitally important that first steps be taken now to overcome the present inertia. Perhaps the most immediate requirement is to arouse our citizenry to the facts so that an informed public opinion may better judge what action should be taken. It is the committee's hope that the material on the following pages may provide the basis upon which a beginning can be made in the direction of constructive action. An interim report, based on this material and other studies undertaken by the Research and Development Subcommittee, is currently under preparation and will be submitted to the full committee early this summer.

It is obvious that the problem is large in scope and complicated in nature, and that any effective solution will require cooperative action of the various branches of Government, educational institutions and associations, and most of all our private citizens. For, in the final analysis, it is our private citizens, the parents of the coming generation, who will play the most vital role in guiding the destinies of our youth and, through them, of our Nation.

MELVIN PRICE,
Chairman, Subcommittee on Research and Development.

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SHORTAGE OF SCIENTIFIC AND ENGINEERING MANPOWER

TUESDAY, APRIL 17, 1956

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
SUBCOMMITTEE ON RESEARCH AND DEVELOPMENT,
Washington, D. C.

The subcommittee met at 10 a. m., pursuant to notice, in the old Supreme Court chamber of the Capitol, Hon. Melvin Price (chairman of the subcommittee) presiding.

Present: Representatives Price (presiding) and Hinshaw.

Present also: George E. Brown, Jr., of the staff of the Joint Committee on Atomic Energy.

Representative PRICE. The subcommittee will be in order.

This hearing which we are about to embark on is by authorization of the full committee. This is the first of several to be held by the Research and Development Subcommittee of the Joint Committee on Atomic Energy to discuss the shortage of scientific and engineering manpower in this country, particularly as it affects our atomic energy program.

A major objective of this hearing is to develop greater public awareness of this important problem and perhaps to reach some tentative conclusions as to what direction our efforts should take.

As this committee is primarily concerned with atomic energy matters, I think it is appropriate that our first witness is Dr. Libby, a member of the Atomic Energy Commission.

I would like to welcome you, Dr. Libby, and hope that you will express your views on this subject and it is our pleasure to have you before our committee.

Dr. Libby is a recognized expert in scientific manpower, and I am certain that what he has to say will be of considerable interest to all of us.

Dr. Libby, would you start things off for us.

STATEMENT OF DR. W. F. LIBBY, MEMBER OF THE UNITED STATES ATOMIC ENERGY COMMISSION; ACCOMPANIED BY EDWIN E. FERGUSON, DEPUTY GENERAL COUNSEL; AND DR. GEORGE G. MANOV, ASSISTANT TO COMMISSIONER LIBBY

Dr. LIBBY. Mr. Chairman, I am very pleased to be able to discuss with you today some of the important aspects of the shortage of scientists and engineers. While I am appearing as a member of the United States Atomic Energy Commission, I have a related background in the matter as a professor of chemistry on leave from the

University of Chicago. I should like to stress at the outset that this country is in urgent need of many more trained personnel in science and engineering. In our own field of atomic energy, the lack of scientific and technical personnel is considerably more serious than lack of money or raw materials as a limiting factor for the future.

Although my remarks will be directed primarily to the atomic energy field, it should be remembered that the problem is a broad one and must be approached on a cooperative basis by many groups, both public and private.

The President's awareness of the critical situation has resulted in the establishment of two groups to recommend action in this area. On April 3, President Eisenhower created a National Committee for the Development of Scientists and Engineers with representation from the major interested groups in our economy to provide the mechanism for common effort in meeting the crisis. On March 28, the President's Committee on Education Beyond High School was established to consider recommendations for steps to meet any shortage in scientific, engineering or other professions. The Commission will cooperate with these groups in every possible way.

The Atomic Energy Commission has been keenly aware for some time of the general shortage of highly qualified scientists and engineers in this country. The report prepared by Mr. Collingwood, of the Library of Congress staff, and published by the Joint Committee, presents an excellent summary of the statistical information available on this important problem. Studies by such organizations as the Engineering Manpower Commission and the Scientific Manpower Commission have established that the immediate needs of the Nation for scientists and engineers are not being met and will not be met over the next several years. While we can expect the number of graduates in science and engineering to increase, it is not likely that there will be enough highly qualified scientists and engineers in the foreseeable future to meet the surging demands of our economy. Further, interviews with officials of approximately 200 large companies by the Bureau of Labor Statistics for the National Science Foundation in 1954 suggested that the problem is not only one of numbers alone, but of quality as well. The nature of our advancing technology with the role of science becoming ever more important suggests a technical manpower problem that will be with us for many years to come.

Considerable attention has been focused recently on the gains in science by the Soviet Union. While we are now virtually equal with them in the numbers of engineers and scientists, they are leading us in the number of new graduates per year. Although it may not be possible or necessary to match them on a strictly numerical basis, we must take measures to increase the number of our engineers and scientists and to more than match Russia on a quality basis. Time and time again we have seen what can be accomplished by just a few individuals of very high caliber working toward a common end.

The atomic energy program has not been free of difficulties in recruiting and maintaining a staff of qualified scientists and engineers. There have been specific indications of shortages of scientific manpower. One of these has been the inability of the AEC to staff its own training schools adequately. Another has been related to the Commission's recruiting efforts at colleges and universities. We have

found on most campuses extremely competitive bidding for new engineering and scientific graduates, most of whom have a choice among several attractive job offers.

While the conditions just described have not as yet had a serious impact on our basic program we are quite concerned about the scientific manpower outlook in relation to the needs of the emerging atomic energy industry. The Commission surveyed some 200 companies either already engaged in atomic energy activities or contemplating entering this field. This survey emphasized that there will be a great discrepancy between the numbers of nuclear scientists and engineers that industry expects to obtain during the next 3 years and the foreseeable supply of nuclear scientists and engineers during the same period.

As the Commission has indicated in recent testimony before the joint committee, the total estimated amount of electrical generating capacity from nuclear fuel will be 50 to 60 million kilowatts in 15 or 20 years as contrasted with essentially none at the present. There obviously will be a need for a considerable number of trained nuclear scientists and engineers. In addition, substantial numbers of technically trained manpower will also be required by the rapid growth of many other applications of atomic energy such as nuclear propulsion systems and radioisotope utilization.

The shortage of scientists and engineers is not the result of any single factor. We all know of the demands placed on our scientific resources during World War II by the military program including the Manhattan District. After World War II industry and the universities accelerated research and development, and the defense programs continued. The Korean fighting brought new high levels of research and development for defense. The situation has been further tightened by the growing research and development programs of the Atomic Energy Commission and the rapid expansion of commercial interests in the atomic field.

Another factor raising the demand for scientists and engineers has been the increased use of individuals with these backgrounds in such fields as sales work and general management.

In view of all of the foregoing, I cannot see in the long run the possibility of anything but growing needs for scientists and engineers.

While the demand is climbing to record levels, additions to the manpower supply from the colleges and universities remain low. There are several reasons for this. First, of the secondary school graduates having the capability for higher education, a large proportion never enter college and, of those who do, a large portion never graduate. In meeting this problem we must learn more about motivational factors and the relation of economic incentives to them.

Second, too often high-school students do not have an adequate opportunity to prepare for, or become interested in, science and engineering work. About one-half of the high schools do not offer laboratory courses in chemistry or physics. An important problem in this respect is the availability of high-school teachers in science and mathematics who can stimulate interest in these subjects. For financial reasons, many of the best qualified teachers have left the profession. Even more important, though, we are not attracting a sufficient number of young people into science and mathematics teaching. Compared to other fields, the financial rewards are small. At the present time high-school teachers in large cities receive real

pay about equal to that received in 1904, while the pay of labor, in general, has doubled or trebled, and other professions have made very significant advances. With the increasing number of high-school students, the problem of attracting qualified science and mathematics teachers becomes vitally important.

Third, a factor contributing to the small number graduating from our colleges in all lines of study during the last several years has been the low birth rates during the depression. However, the number graduating can be expected to increase because of the higher birth rates since the beginning of World War II. Finally, until recently the pay and prestige incentives to pursuing careers in engineering and science have been less attractive than those of other professions requiring less intensive and difficult preparation.

The problems in the atomic energy field are different in some respects from those in the overall economy. The field is still so new and has grown so rapidly that the supply of qualified teachers is still extremely limited. Along with the need for teachers in the atomic energy field there is need for special physical facilities, organization of courses and preparation of texts.

We must rely primarily on the regular educational institutions of this Nation to provide the necessary scientists and engineers for the growing atomic energy industry. There are certain types of assistance that the AEC can provide these institutions. The high schools, universities, and colleges need assistance in training faculty and obtaining equipment for use in teaching. The Commission has been providing some such assistance and plans to expand its activities.

In addition, for the interim period until the educational institutions are geared up fully to meet professional manpower needs of the atomic energy industry, the Commisison is conducting certain programs to meet current professional manpower needs in the atomic energy field. The Commission likewise plans to expand these efforts.

I would now like to discuss some of the specific programs undertaken by the Commission to aid the educational institutions and to meet current manpower needs in the atomic energy field.

I. ASSISTING EDUCATIONAL INSTITUTIONS

(*a*) Faculty training: One of the problems of colleges and universities in assuming their proper roles and responsibilities in atomic energy curricula is the lack of faculty members trained to teach nuclear energy courses. The Commission has established summer courses to train college and university faculty members at Argonne National Laboratory and Brookhaven National Laboratory. These courses will provide engineering college faculty members with subject material which can be utilized for teaching nuclear energy. In addition, the Commission employs university and college staff members in Commission laboratories during summer and sabbatical leaves. This enables them to gain practical experience that is useful in teaching nuclear energy courses.

The Commission plans to expand these summer institutes and increase this employment of college faculty members at Commission laboratories.

(*b*) Providing facilities and equipment: Another need of the colleges and universities in undertaking nuclear science and engineer-

ing courses is the need for facilities and equipment. The Commission is starting a program to lend training devices and laboratory equipment such as subcritical assemblies to educational institutions. In addition, we will seek legislative authority this year to enable us to contribute to the cost of reactors and other equipment for the conduct or support of educational and training activities in the fields specified in section 31 of the Atomic Energy Act. The Commission has already established a policy to encourage non-profit medical and educational institutions to acquire research reactors and subcritical assemblies by making available without charge reactor fuels, fuel solutions, heavy water, and neutron sources.

(*c*) Teaching and textbooks: The Commission has taken other steps to aid in establishing courses in nuclear science and engineering. Scientists from the AEC facilities have been traveling to university campuses to lecture, conduct seminars, take part in colloquia, and carry on other related activities. Further, we propose to loan AEC and AEC contractor personnel to colleges and universities for appointment as "visiting professors" for 1 year. These persons will teach and otherwise assist the educational institutions in establishing courses of instruction and curricula in nuclear energy technology.

The Commission has, in addition, undertaken the preparation of special textbooks and laboratory manuals for use in teaching nuclear engineering subjects. We propose to distribute to college libraries such valuable documents as the Reactor Engineering Handbook and other text material prepared by the Commission and its laboratories.

(*d*) Student motivation: In order to arouse interest in atomic energy careers among college and high-school students and to give them some basic information on such work, the Oak Ridge Institute of Nuclear Studies and Oak Ridge National Laboratory have sponsored a series of symposia and institutes. Further, a traveling teacher program for the secondary schools will soon get under way. Many other activities have also been undertaken upon specific request from schools and school systems.

II. MEETING CURRENT MANPOWER NEEDS

(*a*) Fellowship: In another program, which it proposes to enlarge, the Commission sponsors a number of graduate fellowships to increase the supply in the following specialized fields of particular interest to it: Radiological physics, industrial hygiene, and industrial medicine. While the fellows have no direct obligation to the AEC or its contractors, it is hoped that the majority of them will contribute their specialized skills in the atomic energy field whether for government, industry, or universities. These fellowships do no conflict with the broader program of the National Science Foundation where the fellow is not restricted as to scientific or engineering field.

(*b*) Training courses: In another area, the Commission operates a few special training schools. These serve its own needs and provide technical knowledge to personnel outside the atomic energy program; thus, filling the gap until such training can be undertaken by educational institutions. The Commission sponsors the operation of reactor technology training schools both at the Oak Ridge National Laboratory and the Argonne National Laboratory, and the Oak Ridge

Institute of Nuclear Studies offers courses in techniques of using radioisotopes.

(*c*) Participation on atomic energy research programs: In addition to the direct training activities discussed above, training is provided incident to other programs of the Commission. Graduate students are frequently employed as research assistants on the Commission's research contracts with colleges and universities. Further, many of them are given an opportunity to undertake their thesis work at one of the national laboratories. Finally, many of the AEC facilities employ both the graduate and undergraduate students as well as faculty members during the summer months. Industry personnel also have been participating in increasing numbers in programs of AEC contractors. They actually work at contractor facilities for a period of a few months to 2 years gaining valuable experience to carry back to their own companies and also making a valuable contribution to the Commission's program.

Such arrangements benefit the Commission by bringing to its activities specialized talent not otherwise available. They also benefit the atomic energy industry and the colleges and universities by affording opportunities for practical experience.

In conclusion, the general shortage of scientists and engineers is a limiting factor in expanding scientific programs in our economy. In fact, it is the most severely limiting factor, and one which will be with us for many years to come. We hope that the many attractions of a career in the atomic energy field will minimize the effects of the shortages of engineering and scientific manpower on the atomic energy program. However, the increasing requirements in this field will further tighten the general market.

The immediate problem in atomic energy is lack of trained faculty personnel and inadequate equipment and facilities at universities and engineering schools. The AEC, as I have reported, is playing a part in alleviating these shortcomings and proposes to do more in the future. Eventually, the Commission's emergency programs in this area will decrease as the colleges and universities become able to assume more of this load. That is as it should be.

The two recently established Presidential committees—one on the Development of Scientists and Engineers and the other on Education Beyond High School—should develop bold, positive programs for meeting the scientific manpower crisis.

These programs will take account of the opportunities and the responsibilities of education itself, of industry and of Government at all levels to build up the numbers and quality of teaching staffs, improve the appeal of careers in science and engineering to our capable young people, and to finance qualified students who would not otherwise be able to prepare for these careers. Many questions will come before these representative groups. Possible examples are:

1. Should there be scholarship programs of broad scope in science and engineering to finance the training of high-school graduates as a means of increasing the supply of urgently needed technical manpower? For myself, I am inclined to think that this may be necessary.

2. Should special aid be provided to raise the salaries of high-school science and mathematics teachers? I believe this also should be given serious consideration.

I think probably high-school teachers in general require a salary raise.

Representative PRICE. Do you have any idea what the average salary of a science teacher would be in high school?

Dr. LIBBY. I have a study here, Mr. Price, which I would recommend to your attention. It is made by the Fund for the Advancement of Education, of the Ford Foundation. It is entitled "Teaching Salaries Then and Now," by Beardsley Ruml and Sidney G. Tickton, as of October of last year.

On page 20 of this study they give the present average salary for teachers in big city high schools. This is as of October of last year, I believe. It is $5,526.

Representative PRICE. Would you care to hazard a guess what a person qualified to teach science in high school might be able to command as a salary in private industry?

Dr. LIBBY. I would say twice that would be a guess. It would vary, of course, with circumstances, but I think that that would be proper as a figure.

Such questions are before us in large numbers. We look to the action committees appointed by the President for guidance in coordinating planning. We look to united follow-up action by education, industry, and Government to win what Chairman Strauss has described as the cold war of the classroom.

Representative PRICE. Dr. Libby, I think somewhere in your statement you indicated that up to now the atomic energy program has not been seriously adversely affected because of the lack of scientific manpower, but you indicate throughout your statement that the time is coming when it may be. Would you elaborate on that for a moment?

Dr. LIBBY. I think beginning in 1940 one can say that there was no serious shortage of technical manpower in the critical parts of the work, and throughout World War II. It is to be remembered that during the early stages of the development, the very critical part of the work involved a relatively small number of very highly skilled people, such as Enrico Fermi. People of that type carried the load and decided whether the project was going to be a success.

Now, later on when the large plants were undertaken, the MED program of the military, where soldiers who were drafted scientists and engineers were detailed back to the Manhattan District for work on the project—that saved our lives. As a result, I think throughout World War II we had no crippling shortage, or no serious shortage of technical manpower in the Manhattan District. But it took some doing to avoid it.

Now, following that, we had a considerable momentum, and there was a difficulty due to the return of some of the leading scientists to the universities, with the result that we had to reorient the magnitude of our efforts. But the numbers of people employed did not drop considerably.

I think to summarize, one can say this: We have been extremely fortunate because our work has been so new and interesting and relative to other fields we have been very fortunate. Now, I think we can see—and especially now that we are going into atomic power—that we are being hurt, and our efforts in atomic power seriously threatened

by the shortage of technical people, especially those who have some knowledge of this esoteric new field, who have had something to do with reactors and atomic energy.

Representative PRICE. Up until now you have not had real serious competition with private industry in the nuclear field.

Dr. LIBBY. Yes.

Representative PRICE. But you are having it now.

Dr. LIBBY. We are beginning to get it, yes, sir. I think it is going to increase in seriousness.

Representative HINSHAW. Dr. Libby, you have said that up to now your program has not been adversely affected. I would like to call attention to this and ask you about the complaints that a number of your contractors have been making—certainly they have been making it to me—concerning the taking of eligible young men into service by the Selective Service system. Now I can think of certain contractors, and you know of them too, who have had very highly important key scientific young men, 26 years old, and thereabouts, who have been deferred 2 or 3 times by their local Selective Service Board and who ultimately have come up to the point where they either had to serve or find some reason why they could not serve.

Is that not adversely affecting the Atomic Energy Commission program?

Dr. LIBBY. It certainly is, Mr. Hinshaw, and I did not mean to imply that we had not been in a tight situation all along. We have been in a tight situation throughout the 20th century. I guess since the beginning of time there has never been a surplus of technically competent scientists and engineers—never.

I think it is always a tight situation. What I meant to say is that it has not been nearly as serious in the past as it is obviously going to be in the future. It was by way of contrasting these two situations that I said that in the past the shortage has not been crippling to us. But that does not mean that we could afford to lose these people. We certainly could not. Every time we have lost a good man we have lost irreparably. There is no doubt about that. (See also letter from Dr. Libby, p. 27.)

Representative HINSHAW. Now, I would like to ask you this. There is a question that has been bothering me for some time. I think it is of prime importance.

Do you join me in thinking that the work of a scientist or a technician or engineer in the field of atomic energy—and, of course, I think of the weapons field naturally—is more important to the welfare and safety of our Nation than his service for 2 years in the Armed Forces?

Dr. LIBBY. I would say, in general, that men who contribute significantly to the program of arming the Western World with nuclear weapons contribute much more by serving the same period of time in the laboratories than they would in the armed services.

Representative HINSHAW. Is there any less hazard, so to speak, for instance, in the Atomic Energy Commission's program than there is in the Armed Forces during any normal time that you can think of except in actual conflict?

Dr. LIBBY. I really would not know about that, Mr. Hinshaw. I would think probably the life in the laboratory is no less hazardous. I really would not know about that but my impression is that neither of them are extremely hazardous in peacetime.

Representative HINSHAW. It is my understanding also.

Dr. LIBBY. To amplify the answer on your previous question, Mr. Hinshaw, I think you touched on something that is extremely important. The armed services need technical people, too. But the technical people that go into the armed services should be used for technical purposes. Now, if we have people applied in our laboratories and in plants that are being utilized and their abilities and training being utilized to arm the country, it seems to me a loss to everyone to transfer them.

Now, of course, there are many social problems involved here which I would not want to discuss, but if you ask me whether it is a loss the answer is very definitely "Yes." It is a loss.

Representative HINSHAW. Now, I do not know what the present situation is as of today in the Selective Service and in the Army, but I have been given to understand that as late as a year ago, there were 7,400 men who were enlisted men under the Selective Service and Training Act in the Army who had what they called a military occupation specialty, or MOS of Scientific and Professional Personnel. That is spoken in the jargon of the Military as an MOS of SPP Now, these men, in order to get that SPP, MOS, had to qualify by being a technical graduate in the first place with a Bachelor of Science degree plus 3 years of experience in the field, or a Master of Science degree and 2 years of experience, or a degree as a Doctor of Philosophy before they could even qualify as a private 1st class for that specialty classification.

Now you find these 7,400 men doing odd things which may or may not be within their field of endeavor. I can think of a recent case where a scientist who had certain qualifications that were of value to the Atomic Energy Commission was placed on a detail as a biologist. He, of course, had no qualifications for that. He did have a scientific degree and apparently the Military thought that because he had a scientific degree he was qualified in all branches of science. I do not know about that, but apparently that sort of a thing had happened.

I have letters in my file which I shall be glad to show you on this subject. I do not think it is necessary to place these things in the record because actually we do not want to clutter up the record with those things. There are just hundreds of them.

I know that I introduced a bill and it was referred to Mr. Price's standing committee, the Armed Services Committee, of which Mr. Vinson is the chairman, on which certain hearings have been held. While the support for that bill very largely came from the outside, from non-Government sources, I found the Government sources very loath to take a position in support of the principles of the bill. Is there any explanation that you can think of as to why the Government sources should take such a position?

Dr. LIBBY. I know of none offhand, Mr. Hinshaw. I am not familiar with your bill. Are you referring to the recent session?

Representative HINSHAW. Yes.

Dr. LIBBY. I am familiar with the amendments to the Armed Forces Reserve Act of 1952, passed last year, which make possible the 6 months basic training and then Standby Reserve status for certain groups of people.

Representative HINSHAW. Now, they go through all of that rigamarole for the purpose of satisfying the accusation that these men

were being let off from military service. Now, actually, they may serve 6 months or 3 months and take a course of training, primary or basic training, and then go into the Reserves. But in order to get there they have to go through Selective Service Boards. Selective Service Boards say whether or not they are qualified for the scientific and professional classification and hence be transferred to the Reserve force. I thought that that was unnecessary. I thought that when they had once achieved the basic training they should then be discharged if they were actually engaged in a pursuit which was considered to be in the interest of the national defense. They can take one position or another, but I place it in the hands of a scientific and professional board and this bill which we passed places it in the hands of local Selective Service Boards.

Dr. LIBBY. I am still hopeful that this will help us, this bill. I think only time will tell. I am still hopeful.

Representative HINSHAW. It is a very indirect bill as far as scientific manpower is concerned.

Now, I have had a number of these men who are presently enlisted in the Armed Forces, generally privates first class, and who have this scientific and professional personnel military occupation status and want to know whether or not they can be transferred into the Reserves for the purposes of getting out and getting into the field of their science. I have learned that the bill and the regulations are not retroactive, and start from the day the bill was signed, so that the 7,400 people who have an MOS of SPP are not able to apply for a transfer to the Reserves.

I have that letter from the Assistant Secretary of Defense for Manpower. Do you not think that it is a little bit ridiculous? He says that they have need for these men. They do in some cases, yes, but they are hiring civilians for $10,000 and $15,000 a year to take the positions and they expect to get a fellow into the Military just because he has those qualifications and get him for $75 a month. That is plus board and room and picking up cigarette butts on weekends.

Dr. LIBBY. I think we do not object to the Armed Forces, of course, having the technical people they need, and they should have them.

Representative HINSHAW. But not as privates, first class. They are qualified to become fairly high ranking officers, it seems to me, at least first lieutenants, if they are of that age group and that qualification.

Dr. LIBBY. The worrisome loss is when they are not employed in their technical pursuits after being drafted. This is the serious thing in a time of shortage. I think one would say that if there were plenty of these scientists and engineers then they should not be treated specially, but in a time of shortage we have to conserve them, or should conserve them.

Representative HINSHAW. You have said on page 7 of your statement that the Atomic Energy Commission will ask for legislation providing for contributions to the cost of reactors and other equipment for educational training activities. When is the Atomic Energy Commission going to present its views formally on that subject?

Dr. LIBBY. We have it under preparation now, Mr. Hinshaw, and it should be ready within 2 or 3 weeks.

Mr. FERGUSON. It is in the process of clearance now with the Bureau of the Budget.

Dr. LIBBY. I notice with interest that Senator Jackson has introduced a similar piece of legislation.

Mr. FERGUSON. It is broader in scope. It would go to assistance in any type of reactor.

Dr. LIBBY. I can explain the problem a little more clearly to you, I think. We are asking the Congress this year for $3 million to supply what we call colloquially "teaching kits," or assemblies of apparatus for laboratory instruction in nuclear engineering. These kits or assemblies of apparatus are similar to the one now in use at the Argonne National Laboratory in the reactor training school, where we have done the training of the foreign students. We would like to spread these around the country, so that the engineering schools can afford these. We can loan them to them and they can get started right away and get to teaching laboratory courses in nuclear engineering.

Representative HINSHAW. I, of course, am familiar with the situation in the part of the country from which I come, namely southern California. I know that the 2 universities, or 3 universities located there, perhaps 4 or 5 of them, are interested very much in obtaining the experience for certain of their graduate personnel on reactors, and yet they find it very difficult to accumulate sufficient funds by grant or gift to acquire this reactor equipment. I presume that after that money has been acquired, it is easy enough for them to get the authority of the Atomic Energy Commission and the special material necessary to fill the core of the reactor.

Dr. LIBBY. Yes, sir.

Representative HINSHAW. Is there any thought that the AEC will attempt to obtain authority from the Congress to contribute to those projects?

Dr. LIBBY. This general authority we are seeking would allow this kind of thing.

Representative HINSHAW. But $3 million would not even be a beginning.

Dr. LIBBY. That is not for reactors; I mislead you, I am afraid, sir. It is for the subcritical assemblies. They are really reactors without shielding, and which will just barely fail to operate, which are used for teaching the principles of neutron moderation and reactor engineering. These things cost a great deal of money, and yet they are indispensable in teaching nuclear engineering. For, an actual operating reactor cannot be operated without shielding because it is radioactive. These reactors you can tear apart and rebuild with your hands, though they have just about as much valuable material in them as a real reactor. For this reason they are too expensive for the schools, in general, to purchase. We consider this in some ways a more immediate need than reactors. The students will learn more in the first instance from building their own reactors, and from studying the laws of moderation of neutrons and the way the physics of reactors operate.

In addition to these subcritical reactors, we have various other pieces of expensive equipment in this assembly. We have the hot loop for studying the heat transfer from metallic sodium and facilities for handling radioactive materials—highly radioactive materials—metallurgical facilities for studying the metals of interest to atomic energy.

Now, what should be done is that each school should have this kind of equipment on its own campus, but then near it within convenient distance so the students do not have to travel very far, there should be a reactor in each locality, so that the students, say, in your district would not have to travel very far in order to do their experiments on a reactor. I am not convinced it is necessary to have a reactor on every campus in the country. I think that it is necessary to have some laboratory equipment for nuclear engineering on every engineering school campus. We must have a placement of reactors around the country so that students can get their hands on them and do a certain number of experiments with them, to familiarize themselves with it.

It is for this latter purpose that we seek this authority, to help the schools do this important job of making reactors available to the students.

Now, you know there are 2 already, 1 at Pennsylvania State, and 1 at North Carolina State College, and there are some more under construction. MIT has one building and UCLA is considering one.

At the moment we have no authority to help them in any way except to grant the heavy water and uranium and waive the use charges.

Mr. FERGUSON. We have a problem under section 169 of the act, the no-subsidy provision, which provides that appropriations shall not be used to provide assistance to licensees, section 103 or 104 licensees, except under section 31 contracts.

Representative HINSHAW. What would it take to amend the law to permit that? It seems to me that one might put the simple words "except educational institutions," into the section and completely change the picture so far as you are concerned; would it not?

Mr. FERGUSON. Our approach, I think, is going to be to add a little language to section 31 which would make it entirely clear.

Representative HINSHAW. Then, I think that that should be presented to the committee as soon as possible, because the session is drawing to a close.

Dr. LIBBY. We will do it, sir.

Representative HINSHAW. We will have to pass that law and also obtain funds for the AEC to operate in the coming year. We have very few months in which to operate.

Representative PRICE. What would it then permit you to do, Dr. Libby, that you are not in a position to do now, under section 31?

Dr. LIBBY. My understanding, and Mr. Ferguson will check me on the legal aspects, that we cannot buy part of the reactor at the moment. We can loan equipment and we can loan the fuel and we can pay fuel-processing charges, but we cannot build the reactor proper.

Representative PRICE. This will enable you to build the reactor for a university.

Mr. FERGUSON. Or contribute toward defraying the cost of construction, or operation, or both.

Representative HINSHAW. Have you completely outlined the program that you are trying to get together for presentation to the Congress?

Dr. LIBBY. As far as it concerns training of scientists and engineers, sir.

Representative HINSHAW. And the supply of material for reactors and so on, whatever is necessary for the increase of the kind of people we are talking about in numbers and quality?

Dr. LIBBY. I did not mention, of course, the impact of the Geneva Conference. We produced in the Geneva Conference quite a library of materials, you know, which has been of inestimable value in instruction in nuclear engineering. I think that I have omitted none of the important or essential things. I have omitted a few peripheral things like the Geneva Conference which has a bearing on the educational program. I might say in general that there is one other thing we do. That is at every occasion, whenever we have an opportunity, we make it known that we like to have people present us with challenges and ways in which we can help in this serious problem. I am sorry to say that in most instances it is out of our province.

Representative HINSHAW. Let me point out, Dr. Libby, or let me ask you concerning this visit which we were favored with last week in which the committee entertained some 45 visiting student scientists who are here for the purpose of, I presume, learning something of our reactor technology—is the same thing available to our own students as is available to foreign students?

Dr. LIBBY. Well, we have for years operated a classified reactor technology school at Oak Ridge. Now, at the moment there is very little difference, I would say, because there is so little left in reactor technology business which is significant that is classified, at least in the learning stages. The classified materials is of really minor importance.

Representative HINSHAW. Supposing we have a group of students similarly qualified to these people who came here—and I understand they were highly qualified——

Dr. LIBBY. Yes, they are highly qualified.

Representative HINSHAW. From UCLA—you mentioned that a moment ago, the University of California at Los Angeles, could they apply for and receive the same training and the same benefits in the course of training as these foreign students?

Dr. LIBBY. We have a certain number of places in our school, each class, which are for Americans. I will have to get the details on that. I will ask Dr. Manov the exact number. The next class is to have 120 students in it, and there are 45 foreigners. I think these are the right numbers. The answer is that we take a certain number of Americans, of course, and in addition we have the Oak Ridge school. I do not say it is enough, Mr. Hinshaw, and I think the only answer is that we will get schools like the leading engineering schools equipped to teach this laboratory course. You see they do a fine job on the theory now, and what they need are some apparatus so they can give them the practical instruction.

Representative HINSHAW. I just wanted to be sure that we are offering the same facilities to our own students that we offer to foreign students.

Dr. LIBBY. To a limited number. But I would not want to mislead you. We simply cannot take more than a limited number. The way out we are seeking is to get the regular engineering schools and help them become equipped so they can carry the load. That is the policy.

Now, I think that it will come about. Frankly, I wish that it would move a little more rapidly. I think we will make it this way.

Representative HINSHAW. In the conclusion of my questioning, Mr. Chairman, I would like to call attention to the fact that the gentleman's committee, his standing committee, might very well amend the Reserve Act to apply retroactively to those who are already in the service so that they may be released into the Reserves having served 3 months or 6 months or whatever the qualifications are, and thereby become immediately available, some 7,400 of them, to the industries and the Atomic Energy Commission and other Government projects.

I would hope that that could be done.

Representative PRICE. As the gentleman from California knows, I am in sympathy with his objective and I also know that he realizes the stone wall that we have run up against in trying to get action on his proposal.

Representative HINSHAW. This is a different proposal I am letting mine go by now to the point where I suggest that the present act be amended to provide for retroactive consideration of those who are already in the service. The trouble with the law is that it provides for the person who is necessarily drafted from a position in industry or government. He is then allowed to return to that position. But it does not provide for the man who was drafted before the effective date of the act and has been taken from the Government or industry and who wants to go back. The cutoff date is as of the date of passage of the act.

Representative PRICE. Dr. Libby, on page 6 of your statement you began to discuss the activities of the AEC in assisting in the training of technical manpower. You mentioned certain types of assistance that the AEC can provide these institutions, and you said the high schools, universities, and colleges need assistance in the training effectively and obtaining equipment for use in teaching. I notice, however, in following through your statement there, you do make reference to what you are doing for colleges and universities; and, while you mentioned high schools on page 6, I do not believe anywhere else in your statement you give any indication of what you are doing to help in the high school field.

Dr. LIBBY. Well, the first thing is that we have an open mind and we are open to suggestions for any ways in which we can help. It seems to me that we can offer opportunities for the high school teachers to learn about atomic energy and things of this sort if they wish. We can also furnish exhibits and materials for them to use in teaching and we can just occasionally make available new types of experiments which they can use in their high school teaching.

I think in general, if one finds a more interesting facet of science, it makes science more interesting in general, but we will make isotopes available to high school teachers for their use in teaching, and we try to be as helpful as we can.

I would like to refer this question for more details to one of our staff members who knows this, if you wish.

Representative PRICE. Are there any instances in which the high school departments do avail themselves of the services of the Commission?

Dr. LIBBY. May I ask, is there anyone here from the Commission to answer that?

Dr. MANOV. Yes, Mr. Price, there is considerable activity in the high schools, and there are available various types of Commission

assistance. We started out back in 1950 to write a textbook called Laboratory Experiments with Radioisotopes in cooperation with the New York public school system. This has been distributed through the Government Printing Office, and three or four thousand copies have been made available. The high schools call upon us to provide speakers before symposiums of various types they hold, and the Commission has always responded. We have gotten into the business of providing radioactive or tagged compounds in small quantities which can be obtained without AEC redtape. These are teaching quantities and perfectly safe even if you drank them. They are designed that way. They are proving to be a considerable aid in teaching radiochemistry in the high school chemistry curriculums. (See also letter from Dr. Libby, p. 27.)

Representative PRICE. Now, Dr. Libby, you explained the effect on the training program and so forth of offering the assistance to various educational institutions. That would seem to me making your facilities available to those professors and teachers that desire to come in and do summer work and so forth. Do you have a program where the Commission might send instructors into the university and make loans of some of your people rather than placing the initiative on the part of the professors coming in during the summer and working in your laboratories?

(See also letter from Dr. Libby, p. 27.)

Dr. LIBBY. Yes, I believe I mentioned briefly, Mr. Price, that we have such a plan. I am afraid it has not been activated too fully yet. You know, the shortage was such that we had not been pinched much in the past, but we do sometimes feel the loss of a man for a year. In general, it is a good thing, and we will look with favor if we can on this kind of thing. I think it is a good thing to do.

Representative PRICE. Now, you also said, on page 4, that another factor in the demand for scientists and engineers has been the increased use of individuals with these backgrounds in such fields as sales work and general management.

How true is that?

Dr. LIBBY. Well, I would refer to Mr. Collingwood's very competent statement.

Representative PRICE. Do you have any experience with it? You have a lot of contractors working with the Commission; do you have much experience with it in your own program?

Dr. LIBBY. Oh, yes, it is, in general; so that people who are in charge of or at least involved in many of the critical decisions have technical background, and they almost have to have. Now, of course, it does not mean that they all do. But our program is so technical that it is necessary in most instances that there be some understanding of it.

Representative PRICE. That is just another reason why you need more engineers; is it not?

Dr. LIBBY. I would like to say in that connection that even if we get a surplus, this will be a very great benefit. I see that scientific training is a good general background for all sorts of things. I do not see that people need mind about that. Good mathematics and good basic science, I think, are helpful to people. It would not be any tragedy if we did produce a few more than we could immediately use.

Representative PRICE. You would need them in the business.

Dr. LIBBY. We could find other jobs for them.

Representative PRICE. You could find other technical men to do these jobs.

Representative HINSHAW. I might call attention to the gentleman from California sitting alongside you, being technically trained and his technical training having gone astray in the field of politics.

Representative PRICE. I think it has not gone astray; it has been very valuable to the members of this committee.

Representative HINSHAW. I thank you.

Representative PRICE. Would you say that the AEC situation is worse now on this particular point than it has been and it is getting a little tougher all of the time?

Dr. LIBBY. There is a considerable tendency to fill some of the administrative jobs with technical people, yes. I do not deprecate this. I do not know quite what to do. It seems to me that the program in our laboratories, and these companies going into the atomic power business—they have to have people in policy positions who understand it and I am afraid you have to do it. It is part of the growth of the business. I do not see any way out of it.

Representative PRICE. Now, just to give the committee a little feel of how extensive your reactor training program is with the educational institutions, would you explain that to us dollarwise?

Dr. LIBBY. We are going to run one summer course this year at the Argonne Laboratory, in the Reactor Training School. Could you give them the details on the number of that?

Dr. MANOV. I do not have that here.

Dr. LIBBY. We will have to get you those numbers, and it is in the process of happening now, and just how many people we are going to have and how many takers we are going to have. It is substantial. We hope it will make a real dent. (See also letter from Dr. Libby, p. 27.)

You see, I do not want to imply at all that the engineering professors and the engineering schools are not well trained. They are. But the point is that atomic energy has some new facets in it, and I have never actually worked with this laboratory equipment in the course of my years as professor at the university, and I would be very happy to go take that summer course and have a chance to work with these pieces of equipment and learn about them.

I think it is in that spirit that we offer this, and in no spirit of criticism at all.

Representative HINSHAW. Mr. Chairman, I recently had the privilege of sitting with the American Society of Professional Engineers at their annual meeting held here in Washington at which certain questions were passed back and forth and answers sought to those questions.

One of the questions was, how do you think that we, being the Society of Professional Engineers membership, could contribute to this program which is lagging in the high schools and in the colleges?

It occurred to me right at that time that the members of the engineering and scientific professions who are engaged in Government and industry could do very much as the members of the College of Physicians and Surgeons and lecture at high schools and colleges on their favorite subjects. They could go upon invitation from the

high school, for example, and give a lecture on chemistry, or electronics, or whatever, in a more or less nontechnical way at that stage, of course, but at least be an inspirational lecture which would encourage the youngsters to go on in the study of science and engineering.

Dr. LIBBY. This certainly is an excellent suggestion. It is being implemented in some localities, right here in the District. There is quite a bit of that activity going on. It is an excellent suggestion and it will help.

Representative HINSHAW. They might even take up parttime teaching jobs, those who have advanced far enough to be able to afford the time, and really contribute a great deal to the educational program.

Dr. LIBBY. About a month ago the teachers in the District were advised to attend a meeting, a teacher's institute, and in order that they be excused from their classes the Council of Engineering Societies in the District took on the job of supplying teachers for the classes and they took them over and I have not heard how successfully, but I imagine quite successfully.

Representative PRICE. Dr. Libby, in your statement on page 7, you treat on the matter of the effect of faculty training assistance in the educational institution. Do you think that this is the best way to do this job or do you have some other suggestions, like loaning teachers and so on?

Dr. LIBBY. I think we should do everything. This is one of the things that we can do, but another thing we can do is make our national laboratories centers in this effort, so that the schools surrounding a given national laboratory will feel free to talk to the director and ask for assistance.

Representative PRICE. Do we do that now?

Dr. LIBBY. We do some of it. I think we could probably do more. It is a question of everyone's realizing the need of just what should be done, and we are sort of going at it together. I think that the schools feel that the Atomic Energy Commission is very friendly in this regard and will be reasonable and helpful insofar as it can. That certainly is our policy, and we want to do everything we can to promote this. But the shortage is a broader thing than just atomic energy and we do what we can but we can attack only a part of the problem.

Representative PRICE. I wonder if you could amplify your remarks in your statement regarding the need for quality as well as additional quantity of scientists and engineers.

Dr. LIBBY. I certainly would be pleased to do that, Mr. Price.

Some of the most difficult jobs cannot be done except by the most skilled and gifted scientists and engineers. Large numbers of people will not avail in certain of the more difficult jobs. Only extremely rare gifts and abilities will help.

Now, there is no dispensing of this requirement. I hesitate to give examples, but I think it is fair to say that Dr. Fermi's work in the development of the chain reacting pile required a gift and an insight and understanding which was extraordinary, and which was indispensable. We could not have accomplished this in the time or anything like this time in which he accomplished it with less gifted people. It simply would not have been possible. We say, for example, how Germany made relatively less rapid progress and we

understand why. There were certain mistakes made and I am not saying the German scientists were as a group less gifted. But Dr. Fermi was the most outstanding man in the world on this particular subject. He had developed the properties of neutrons and he had developed the theory for their moderation, and he had developed the chain reacting pile theory, and he understood it better than anyone else in the world. It was only by virtue of his extraordinary ability that we made such extraordinary progress in the development of the chain reacting pile.

So quality is indispensable. Numbers will not suffice. That is, except in this sense, that if you get numbers, your chances of getting a Fermi are improved statistically.

Large numbers of competent trained engineers and scientists are, of course, very important in themselves, for most of the jobs do not require the extraordinary genius of an Enrico Fermi to do, although they can do them. They do not require them, and other people can do them.

We should never lose sight of the importance of keeping the ablest people in science and engineering, and we should do everything we can to keep them in it. We also need numbers. However, it is a two-sided blade and we must have the geniuses, and we must have the less gifted people trained in good numbers.

Representative PRICE. In the matter of quantity, we may have it within our power to do something about it, but when it comes to quality, then it is for someone much higher to decide.

Dr. LIBBY. There are a certain number of Fermis in a given generation, and I think to be quite selfish, we have to keep them in science if we can. I think it would serve the public interest to keep them in science.

Representative PRICE. Do you believe that industry is efficiently utilizing its available engineering and scientific personnel?

Dr. LIBBY. I think in general industry does a pretty fair job of utilizing its people. In some instances it may not, but I think in the general average it does pretty well. I would suggest, perhaps, it might improve in some ways, supplying more laboratory assistants, and people of the lower grade of training to relieve some of their more highly trained people of some of the things that they do. But this is not a general criticism, and this applies in a few instances.

I think industry makes fairly good use of its manpower but it is a broad question you ask. I could cite instances of where I think they have not, but I think on the average they have done pretty well.

Representative PRICE. The prestige in this field is very important too, and they would not purposly overlook an opportunity to develop the manpower.

Dr. LIBBY. That is right.

Representative PRICE. What sort of an opportunity, thinking of your laboratories, and I go through them occasionally—what sort of an opportunity is given the average technician to advance in the field?

Dr. LIBBY. We encourage people to study and to improve themselves and we encourage them to do this all of the time. I think I can answer the question that we try to give them every opportunity to improve. I think we have a pretty clean slate on that score.

Representative PRICE. Is it not true that some of the technicians in some of the projects, before they went into the project, had no background at all in scientific work?

Dr. LIBBY. I think that this is true, although I have not in mind any particular examples at the moment. In each of the laboratories there are courses and there are seminars, and there is the opportunity to discuss things with the leading men in the field. We encourage the people to do this, and to improve themselves and the standard of promotion and pay raise pay attention to this point. They are encouraged to do it. I think that you will see that we have a pretty good record in that respect.

Representative PRICE. I was not questioning that, but I was trying to build a picture of the type of work that you have all of the way through your program. I know some that have come right out of high school and operate some of your electronic machines without any previous experience in the field. They do a fine job and they become important in these technical programs also.

Dr. LIBBY. I know one of our most important installations at Oak Ridge has a manager, a technical manager who is a high-school graduate, and he has many people employed who are of higher academic training. He is a very good man, but he came up that way.

Representative PRICE. What would be your estimate—or perhaps if you could give us some idea of the AEC's estimate of the quality of Russian scientists?

Dr. LIBBY. My estimate is that the Russian scientists are very competent. Of course, they are producing them in large numbers. I think that there is a certain sign of youthfulness in Russian scientists. They have not yet as solid a foundation as we have but they are coming rapidly. The quality of their work is excellent, it is first rate. Only the future will tell whether the large numbers being produced now are at the expense of lowering of standards. I do not believe that this is so. I do not think it is so. It might be so. It is difficult for us to compare the courses in training. We have only recently been allowed to visit their schools and to learn about these things and they have a different culture.

I think the Russian scientists are very competent and they have the same number of geniuses that we have, and I think we have every reason to believe that they are fully competent and comparable with our own.

Representative PRICE. Now, to get back to the domestic side of it, I wonder if you could tell us something about your competition with industry for new blood in your program in regard to salaries.

Dr. LIBBY. Well, our salaries are very comparable to industrial salaries. We keep a continuing check. I speak now of course, of the salaries of our contractors, for as you know most of our scientists are not employed by the AEC directly, but by the contractors. We keep a continuing check on this, and we are very comparable with industrial standards. I see a graph I have here of such a study. There is no evidence of any systematic difference between the Government laboratories, the AEC contractors, and private industry in this respect. (See also letter from Dr. Libby, p. 27.)

Representative PRICE. Are you referring now to the Government laboratories as against the contractor phase of your work?

Dr. LIBBY. Yes; I separated those out.

Representative PRICE. You are not having too much difficulty on the beginners, are you, on that scale?

Dr. LIBBY. No. We have two studies here, one for the bachelors, and one for doctors of philosophy, and there seems not to be any systematic difference. We are not ahead of them, and we are not paying higher salaries, and neither are we paying systematically lower salaries.

I think that we are going to see salaries in general rise because of the shortage. They are rising.

Representative PRICE. When we talk about the shortage, I wonder if we could pin it down to your own experience each year, the number of new people that you need in the program, beginners, and how many you are able to obtain and get from the different graduating classes of the universities. Could you give us some of your experience in that regard?

Dr. LIBBY. I have some figures that I give with great hesitancy, because, of course, it is rather difficult to be certain of these things. In reactor technology, we estimate—and these, I must caution you, are estimates as best we can make them—that we will have an annual deficit in reactor technology of about 1,500 people per year. (See also letter from Dr. Libby, p. 27.)

Representative PRICE. Now, you have that now, or you anticipate it?

Dr. LIBBY. We have that now, and we anticipate it for the next 3 years. We have not tried to estimate beyond that.

Representative PRICE. When did that start?

Dr. LIBBY. Well, I would say it began pretty much with our atomic power program, and our civilian atomic power program.

Representative PRICE. And it had been going on ther. for about 2 years.

Dr. LIBBY. Not really full steam, it is moving now. We have what we think is a supply of about 500 per year and we think we have a need of somewhere abound 2,000 per year.

Representative PRICE. 2,000 per year?

Dr. LIBBY. Yes, sir.

Representative PRICE. That is just your reactor technology, and are there any other phases of that?

Representative HINSHAW. I would like to call to your attention that that is a very serious deficit, being 75 percent of the need.

Representative PRICE. That is right.

Dr. LIBBY. It certainly is, Mr. Hinshaw, and as I have said in my statement, it is this rather than uranium or heavy water or money, I think, this is the thing more than anything else that is limiting on the rate of the development of atomic power.

Representative HINSHAW. Under that program, or under that condition, then, certainly some urgent action is required to make up that 75 percent deficit.

Dr. LIBBY. That is why we are running the reactor schools and why we are asking for so much money to help in the engineering school instruction.

Representative HINSHAW. I would like to offer this thought, Mr. Chairman: When the World War II need for airplanes was developed, following the British orders of 800 Lockheed Hudsons, which really began the entire program of expansion of the aircraft industry

in the United States, that tremendous need was developed rather suddenly for large numbers of aeronautical engineers and draftsmen.

At that point they went out into the open field of engineers and engineering technicians such as draftsmen and persuaded people of diverse talents, that is, talents which had been used in other directions than aeronautics, to come in and go to school all over again and take a reorientation course in engineering in the first place and then to give them the technical aeronautical training on top of the technical training which they already had which was necessary to supply this deficit.

Is there any reason why that cannot be done to obtain, if possible, this 1,500 that you are talking about? There are literally, I would say, hundreds of engineers and men with master's degrees who would be delighted, if they could have the availability of it, to attend this Oak Ridge School that you have. Its limitation of 120 students in any class that you are talking about—if that could be expanded into 1,200, it would supply most of that deficit, it seems to me. Or even to 1,500, which would completely supply it. But it would supply it today, if the courses were made available, but they are not being made available. Why not? Are we laggard in the appropriations? Are you short the number of people required to teach it? Is the housing situation such that they cannot be handled? Are there not enough rooms in which to teach them and not enough facilities, or what is it? Why can we not teach them now?

Dr. LIBBY. Well, what we are doing, Mr. Hinshaw, is entirely graduate instruction. Both the Oak Ridge School and the Argonne School operate with graduate engineers as students. In other words, we are taking graduate engineers and scientists and giving them a 1-year course. (See also letter from Dr. Libby, p. 27.)

Representative HINSHAW. What is the total enrollment in that school?

Dr. LIBBY. We have in the Argonne at the moment, this is, I believe, the latest figure, 160 students per year. I will have to check these to be sure that they are right.

Representative HINSHAW. But you need 1,600.

Dr. LIBBY. Now, the Oak Ridge School has about 100 per year.

Now, I must say further, Mr. Hinshaw, that of these 160, the Argonne School is 120 foreigners, so that we have less.

Representative HINSHAW. There you have a net of 40.

Representative PRICE. But the ones that you are talking about at your Argonne School are already trained scientific manpower.

Dr. LIBBY. That is true of the Oak Ridge School also. All we do, Mr. Price, is the kind of instruction Mr. Hinshaw is speaking of, that is, taking a man who is an engineer or scientist, and convert him or give him what we need.

Representative HINSHAW. It is a re-education of the man.

Dr. LIBBY. Yes, sir.

Representative PRICE. Your 1,500 shortage that you are talking about is from your graduating classes each year, that you are unable to obtain.

Dr. LIBBY. That is right.

Representative PRICE. From the universities?

Dr. LIBBY. From all sources, and I would say principally from graduating classes, yes, sir.

Representative PRICE. Universities are about the only source.

Dr. LIBBY. Principally, that is right. Now, of course, it is also possible to train a certain number of people on the job, too, so you can supplement these numbers somewhat by that kind of training. But I think it is fair to say that we are not training nearly as many people as we need to take up this deficit. Now, we hope that the engineering schools will step into this rapidly enough to pick it up.

Representative HINSHAW. They cannot do it without equipment and with this program they would not get the equipment for a number of years.

Representative PRICE. That being true, how can we say, as you say in your statement, that these conditions have not as yet had a serious impact on our basic program? You say that you are quite concerned about the scientific manpower outlook in relation to the needs of the emerging atomic energy industry. It must have some sort of an impact on the basic program.

Dr. LIBBY. It does have an impact on our basic program. You take the weapons laboratories. I say we do not get quite all of the people we want. I think that we do pretty well considering the general shortage. That is why I made that statement. It seems a combination of circumstances, the newness of the business, and other things. We seem to fare relatively better than our competitors in industry.

But in the atomic power industry, the shortage is serious, and there is where the pinch is coming at the moment. It is not that Los Alamos does not need more good people.

Representative PRICE. Is there any other type of technical manpower shortage that the Commission is suffering?

Dr. LIBBY. I think reactor technology is the most difficult. Perhaps I could break this down a little for you. I think reactor technology is the main shortage. It is the growth of this new thing, and this new expansion in industry that is the main thing. It is not that our other fields are not tight, but I believe that the reactor technology is the most serious one.

Representative PRICE. That is the one most disturbing to you?

Dr. LIBBY. At the moment, yes.

Representative PRICE. Now, in talking about your proposed legislative program on the reactors for universities, does the Commission encourage universities to go into this program or is this on the initiative of the university?

Dr. LIBBY. At the moment, the universities must finance the reactor themselves, except for the heavy water and the uranium. This we furnish. Now, we can also do some other things, like loaning them equipment and things of this sort. But we cannot pay for the reactors at the moment.

Representative PRICE. You talked in your statement about the high school situation. Is there anything that you could think of that you could do in the local communities to encourage the improvement of scientific curricula.

Dr. LIBBY. Yes, I would say that this is an individual opinion. I speak as an individual on this. In my opinion, the most helpful thing would be to raise the high-school teachers' pay. I am not speaking specifically of the science and mathematics teachers but in general. That is to get more people into the high-school teaching profession. I think this would help, and this would help more than

any other single thing in my individual private opinion: This, I am afraid, has to be done on a local level, at least it looks like it has to be done on a local level. It is a serious national problem. I think each community has to take the matter under consideration, and do something about it.

The high-school teachers, as I said, are falling away behind in the pay scale relative to other workers in the last 50 years. This is also true of college teachers. But the most immediate thing, I think, is the high-school teachers' salary.

Representative PRICE. Now, aside from the salary which, as you indicated, is probably one of the key factors, are there any other factors involved?

Dr. LIBBY. We must continually remind everyone of the importance of technical training to the national welfare. Of course, this is in the press all of the time, and people are continually saying this, and so I am not sure that we are not doing enough of it but we should continue to do this. Whenever it is possible for industry or government to help in this, we ought to do it. We should keep it as a prime national objective to strengthen our scientific corps. It is a prime national objective.

I think it is a task that has to be done cooperatively by everyone in the country. I think it is that type of a job and it is so big that it is very difficult for any one group to handle it.

Representative PRICE. Doctor, I believe you said somewhere in your statement that the Commission was giving thought to the expansion of its fellowship program.

Dr. LIBBY. Well, just special fellowships there, you see. You see, the law is written so that the National Science Foundation has the function of supplying the broad general fellowships. Our fellowships are given for special purposes, and I cited three examples here, and one was radiological physics. We do give special fellowships, but we do not give fellowships for science in general, the way the Atomic Energy Commission did before the National Science Foundation was started.

Representative PRICE. I note in your conclusions you personally express your belief that probably one of the answers is to provide some sort of scholarships for high-school graduates. Has the Commission ever discussed such a program or thought of ever recommending such a program?

Dr. LIBBY. We discuss this problem as individuals all of the time. However, as a Commission it does not seem to be quite our function to go after this general scholarship thing. That is not really our job.

But as individuals we discuss it and I think there is considerable agreement that this might help, at least in the short-range problem, to encourage some of the more gifted high-school graduates to go into technical subjects. I think that it might help. It would be rather quick, which is an important consideration here. There are various kinds of remedies which will take various lengths of time if brought to bear on the problem. But this is one which in my opinion would bear fruit rather quickly.

Representative PRICE. Would you put any strings on the acceptance of the fellowship?

Dr. LIBBY. Just that they be good people, just as to qualifications.

Representative PRICE. You would not put any requirement of service to the Commission?

Dr. LIBBY. Oh, no, not at all. I think the problem is a national one, and we have to increase the strength of the technical corps as such and we will all benefit.

Representative PRICE. It is just encouragement to young people to go into the technical fields?

Dr. LIBBY. That is right.

Representative PRICE. Do you have any questions?

Representative HINSHAW. I think the salary scale of Ph. D.'s and M. S.'s, and so forth, stems from a long time ago when the general thought on the part of, certainly the American public, was that the football team is more important to the college than, let us say, the scholastic eminence of the teachers. They will give great accent to the football abilities and even pay fairly good salaries, so I understand, to some of the players in certain instances, salaries which the professors themselves would like to be able to achieve. That is found again throughout an industry where the sales force is paid much higher than some of the other parts of the industry, the technical forces, because they are out in the front meeting the customers and trying to sell.

It is also true in the Armed Forces where they give great accent to the so-called command portion of the Armed Forces, and very little accent to the technical side of it, which is so necessary to the operation of the Armed Forces. No one thinks about the engineer officer who is below decks operating the engines of the battleship or carrier, and likewise in the Air Force, one fails to remember very often that there is anybody but the "flyboys" in the Air Force. They forget, though, the airplanes have to be maintained and the excellence of the maintenance has a great deal to do with success of a mission. I think it is just a general characteristic of the American people, but certainly so far as the scientific and technical personnel are concerned the present shortage is going to serve as a booster to the recognition and the wage scales of the scientific and technical personnel. To that extent, it is a darned good thing, in my mind.

Representative PRICE. Dr. Libby, let me get a little clearer in my mind your contemplated program for the universities. In your statement on page 7 you say:

> The Commission is starting a program to lend training devices and laboratory equipment such as subcritical assemblies to educational institutions.

You can do that now under existing law?

Dr. LIBBY. Not quite, we have not the money yet. We will be up to the Congress soon on that.

Representative PRICE. If you had the money, you could do it?

Dr. LIBBY. Yes.

Representative PRICE. Now, on the other program then, is this the item that for which you would need the $3 million?

Dr. LIBBY. Yes, that is $3 million.

Representative PRICE. You said that you were asking for that, is that in this authorization bill now before Congress?

Dr. LIBBY. In the appropriations, yes.

Representative PRICE. Do you need authorization for it?

Dr. LIBBY. We think not.

Mr. FERGUSON. It is in the nature of equipment.

Representative PRICE. Then, you say that you will seek this additional legislative authority to enable the Commission to contribute to the cost of reactors and other equipment for the support of educational activities in the field specified in section 31 of the Atomic Energy Act.

Have you any idea how extensive that program might become?

Dr. LIBBY. Frankly, I do not. We will have to see. We anticipate with this $3 million worth of equipment to have 10 kits, and equip 10 schools right away with the laboratory equipment for nuclear engineering instruction.

Representative PRICE. How will the university qualify to get into the program?

Representative HINSHAW. Does the application go in now, or does it go in next month, or what, and the line forms to the right? You are going to have 100 educational institutions looking for 10 kits.

Dr. LIBBY. We anticipate that we will have to set up—or we have plans in the making for taking care of this. Personally, I think it is a nice kind of trouble. I hope we get the money so that we can do this. If these are very popular and successful, we will see.

Representative HINSHAW. This competition is going to come right over to the Congress as to how much influence we have upon the Commission from the local universities. Now, just do not get us into this picture too deeply, either. They are going to come to me and going to come to Mr. Price and Mr. Anderson and say, "See if you cannot get us one of those 10 reactor kits for the local university."

Representative PRICE. Does the Commission have a number of applications on file from universities wanting to get into this reactor business, that are not now in the program?

Dr. LIBBY. Yes, we have a number of universities. Let me clarify that, Mr. Price. All first-rate engineering schools in the country are giving courses of one sort or another in nuclear engineering. That is, they give the book material, and they give the lecture, and that kind of background material. Now, the deficiency in my view, at least, and the Commission's view, is that they are unable to give the practical laboratory instruction which is so necessary to make many of these concepts real. We want to help supply that deficiency.

Representative PRICE. Could you give us some idea how exclusive the Government aid would be in one of these programs, that is, in one project, for instance?

Dr. LIBBY. I would say that we have about a quarter of a million dollars worth of equipment, I think that is about the number, in one of these kits. There is about a quarter of a million dollars in one of those kits. Of course, the school will have to furnish a place to put it and it will cost them quite a bit of money, and, of course, is one of the criteria that will be involved in that.

Representative PRICE. Is that what the Government will provide?

Dr. LIBBY. The reactor kit, yes. Now, in addition we have $2 million up for fellowships in addition to the $3 million. That is $2 million for fellowships in nuclear engineering, special fellowships, which will help encourage people to go to school and learn this, as Mr. Hinshaw was saying.

In addition, we have the program of assistance on university reactors, such as it is. I mean, it is no minor thing we do, and we lend the fuel and the heavy water and reprocess the spent fuel, and one tends to forget that this is all very expensive material. We do that, you see, and we do that now.

Then we can aid in other ways, too, in the loan of other equipment. But at the moment, that is about as far as we can go. That is about where we stop.

Representative HINSHAW. Mr. Chairman, I would like to ask this question: How many applications for these reactor kits do you anticipate receiving? That is, once the word gets out to these universities that they are available in any number at all?

Dr. LIBBY. It is very difficult to predict. I think we will manage to get rid of the 10 in a very useful way.

Representative HINSHAW. I can get rid of the 10 right in southern California, if you ask me to seal the deal.

Dr. LIBBY. There are now 42 schools, Dr. Manov tells me, that are in the business of giving nuclear engineering instruction. So presumably it would be from those 42 that we would draw.

Representative HINSHAW. Why do you limit your request of the Congress to 10?

Dr. LIBBY. Because it is a beginning, to see how it goes.

Representative HINSHAW. I would suggest that you are getting us into a lot of truble, and when I say "us," I mean Members of the House and Senate. They will lobby in favor of their particular universities which they happen to have in their districts. It seems to me that you ought to ask for the 42 and if we cut you to 10, that is something else.

Dr. LIBBY. We calculated as best we could that 10 was about the number we could handle this next year. This will give us a chance to see this. This is rather a quick matter, and we can get this equipment together and get it going rather quickly.

Representative PRICE. Do you specify in your legislation a limitation on the number?

Dr. LIBBY. Yes, sir.

Representative PRICE. It would not be necessary for you to do that, you could request the basis for the program and be limited by the funds you receive.

Mr. FERGUSON. I do not recall any limitation.

Dr. LIBBY. I am not sure we did specify definitely in the legislation 10.

Representative PRICE. I do not think that would be a proper thing. You can control that by the appropriation.

Representative HINSHAW. Surely. If you come back to this earlier question that I was asking you, why can the number of students not be increased in Argonne and Oak Ridge and thereby supply the deficit for the time being in the personnel trained in reactor technology? What is the reason why that program cannot be increased at once?

Dr. LIBBY. We have two difficulties. One is the space, and the other is staff.

Representative HINSHAW. Space being what, the space for housing or space for teaching facilities?

Dr. LIBBY. Teaching space, and also housing, but principally teaching space. As you may recall, last year we had an item in our authori-

zation for a teaching building at the Argonne, which was eliminated by the Congress.

Representative HINSHAW. By the Appropriations Committee?

Dr. LIBBY. I think so, yes, sir. However, we are not complaining; we are doing the best we can; and there is a point about the Government going into school teaching business. I personally do not like it. I think it is better for the school teaching to be done by the schools. We are in a squeeze here, and we have got to do something.

Representative PRICE. Did that apply also to the training program, and would you prefer that be done also by the schools?

Dr. LIBBY. I would personally prefer that it all be done by the regular colleges and universities. I think that that is the proper way to handle it. But in the situation which has developed as rapidly as this one the Government has to do something to hold the fort so to speak until they have a chance to pick up the load.

Representative PRICE. You are trying to get the production of scientific trained manpower started.

Dr. LIBBY. That is right.

Representative HINSHAW. I would say some drastic steps should be taken and we would be glad to receive the recommendations of the Commission.

Representative PRICE. Thank you very much, Dr. Libby. Unless you have something more to say——

Dr. LIBBY. I would like to supply for the record more accurate figures on the enrollment at the Argonne and Oak Ridge Schools, if you will allow me, Mr. Chairman.

Representative PRICE. Thank you, we will be glad to have that, and thank you very much for your usual fine presentation. And thank you, Dr. Manov, and Mr. Ferguson.

(The material referred to follows:)

UNITED STATES ATOMIC ENERGY COMMISSION,
May 4, 1956.

Hon. MELVIN PRICE,
House of Representatives.

DEAR MR. PRICE: It was indeed a pleasure for me to appear before your subcommittee on April 17 to present the views of the Atomic Energy Commission on the shortage of scientists and engineers. The attention you and your colleagues are giving to this important problem will help to focus national attention on a critical situation.

During my testimony a number of points arose which I believe need some clarification. I also promised to furnish some material for the record. There follows what I consider necessary to fulfill my obligation in connection with your hearings:

1. On page 19, (hearings, p. 8) there is discussion of the AEC's problem with respect to Selective Service callup of its contractors' engineers and scientists. I have looked carefully into this matter and would like to report to you some statistics that have been recently gathered.

As of March 31, 1956, AEC's major operating contractors employed a total of about 80,000 personnel, including some 15,000 scientists and engineers. Approximately 1,200 of these employees had been deferred by draft boards on occupational grounds. About 400 had been in deferred status less than 1 year, 360 from 1 to 2 years and 500 over 2 years. Those who have been deferred 2 years or longer fall principally in the occupational categories of physicists, chemists, and engineers. Although the total number of employees who have recently been lost to the draft despite contractors' requests for deferment has not been large (43 in the past 12 months, principally persons with backgrounds in the physical sciences and engineering), the loss of any of our trained scientific and technical personnel can be a serious matter. Furthermore, in order to secure

a deferrent it is frequently necessary for our professional staff to spend considerable time in negotiation with the Selective Service System at different levels.

2. Beginning on page 50, (hearing, p. 21) of the transcript there was mention of the 2 schools of reactor technology sponsored by the Commission—the 1 at the Oak Ridge National Laboratory (Oak Ridge School of Reactor Technology), dealing with classified material and open to United States citizens only, and the 1 at the Argonne National Laboratory (Argonne School of Nuclear Sciences and Engineering), on an unclassified basis and open to both United States citizens and foreign students. For the record, I should like to provide further data on the enrollment at these two schools.

Since its inception the Oak Ridge School of Reactor Technology has graduated 374 individuals. Currently, there are 95 students enrolled and the number will be increased to approximately 120 for the class to begin next September.

The school at Argonne has been in operation slightly longer than 1 year, graduating a total of 39 with 61 additional students now attending. An additional 62 are in training at Pennsylvania State University and North Carolina State College and will come to Argonne in the fall upon completion of this phase of their training. As was the case at the Oak Ridge school, it is expected that the annual rate of graduates from Argonne will be about 120 per year.

Considerable interest was expressed by the subcommittee in the number and percentage of foreign students at the Argonne school. In the first class of 39 students 30 or 77 percent represented foreign countries; in the second session 39 of the 61 or 64 percent were from foreign countries; and in the next class 47 out of 62 or 76 percent will be from foreign countries. Thus something on the order of 70 percent of the student body at the Argonne school has been composed of foreign students in connection with our obligations for training reactor technologists for other nations.

3. On page 38 (hearing, p. 16) of the transcript the question was raised as to the size of our training program in reactor technology. For fiscal year 1957 almost $5.6 million are proposed for educational and training programs in reactor technology. Broadly, these programs break down as follows:

PROPOSED FISCAL YEAR 1957 BUDGET FOR TRAINING AND EDUCATION IN THE NUCLEAR ENGINEERING SCIENCES

Budget data

Training equipment		$3,000,000
Reactor services		400,000
Research training		100,000
Faculty training		450,000
National Laboratory schools:		
Oak Ridge School of Reactor Technology	$283,000	
Argonne School of Nuclear Science and Engineering	650,000	
		933,000
Short term training		150,000
Fellowships and scholarships		450,000
Texts, manuals, library references		100,000
Total		5,583,000

4. On page 36 (hearing, p. 15), there was a question with respect to what I termed "visiting professorships" in my formal presentation. (See p. 11 of the transcript.) I feel some elaboration of this particular program would be helpful to the subcommittee. We have budgeted for this program for fiscal year 1957. Actually, it is an exchange program where both the university and the AEC and its contractors would benefit. One of the deterrents to a program where professors come to commission facilities to participate in research work is the scarcity of other professors and instructors to absorb the teaching load. In the proposed exchange program the AEC and AEC contractors would provide personnel to assume the teaching and other duties of a professor while he is on leave of absence as a research participant at the AEC facility. This will permit our people to gain new contact with professional life on university campuses. It is expected that the AEC or AEC contractor, as the case may be, will continue the salary of their employee while he is at the university. Similarly, the university will continue to pay the salary of a professor who is on leave at one of the national laboratories.

5. On page 46 (hearing, p. 19), I made some comparisons of salaries for research scientists and engineers employed by private industry, by Government laboratories, and by AEC contractors. For the record, I should like to attach the graphical material from the 1955 national survey of professional and scientific salaries of the Los Alamos Scientific Laboratory on which I based my statements.

6. On page 48 (hearing, p. 20), there is discussion of a deficit that I mentioned of some 1,500 reactor technologists for each of the next 3 years resulting from a requirement of 2,000 per year and a supply of only 500 yer year.

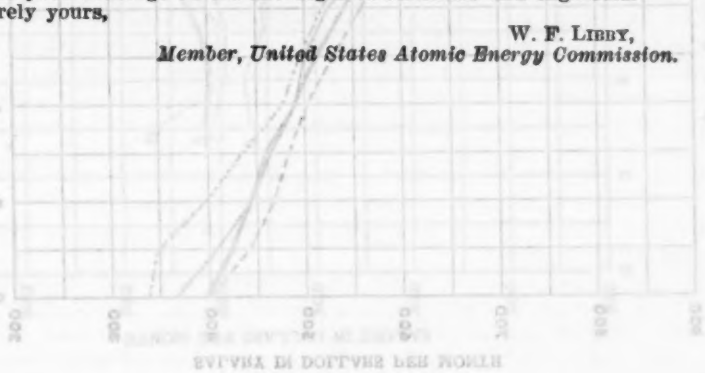
The data on requirements are based on a survey in which about 100 of 200 firms contacted responded. Since, in most studies of this type, firms tend to overestimate their needs, the numerical shortage of 1,500 per year deficit appears to be a maximum figure. I would not hesitate to state that our needs for reactor technologists over the next few years will be greater than our supply. However, the exact extent of the shortage is highly speculative.

7. Finally, on page 35 (hearings, p. 15), Dr. Manov elaborated on some of our programs with the high schools. In addition, we provide kits of published materials to high-school students and teachers upon request in order to make them aware of the opportunities and information in the atomic energy field. Of course, we keep these kits up to date so that the one sent out now might be very different from the one sent out a few years ago. As an indication of the increased interest in just this kind of help, 860 student kits and 154 teacher kits were provided in the first 3 months of 1950; 1,372 students kits and 407 teacher kits in the same period of 1955; and 1,729 student kits and 530 teacher kits in the first 3 months of this year. Of particular significance was the large increase in requests from teachers. While these numbers show the relative increase in demand for information from the high schools, the absolute figures would be considerably larger since many additional kits have been furnished by our operations offices. Since I thought you might be interested in what these kits contain I am enclosing the one we are currently using for high-school students as well as the one for high-school teachers.

I would be most happy to fulfill any additional requests for material the subcommittee might have. Thank you again for giving me the opportunity to participate in your hearings on the shortages of scientists and engineers.

Sincerely yours,

W. F. LIBBY,
Member, United States Atomic Energy Commission.



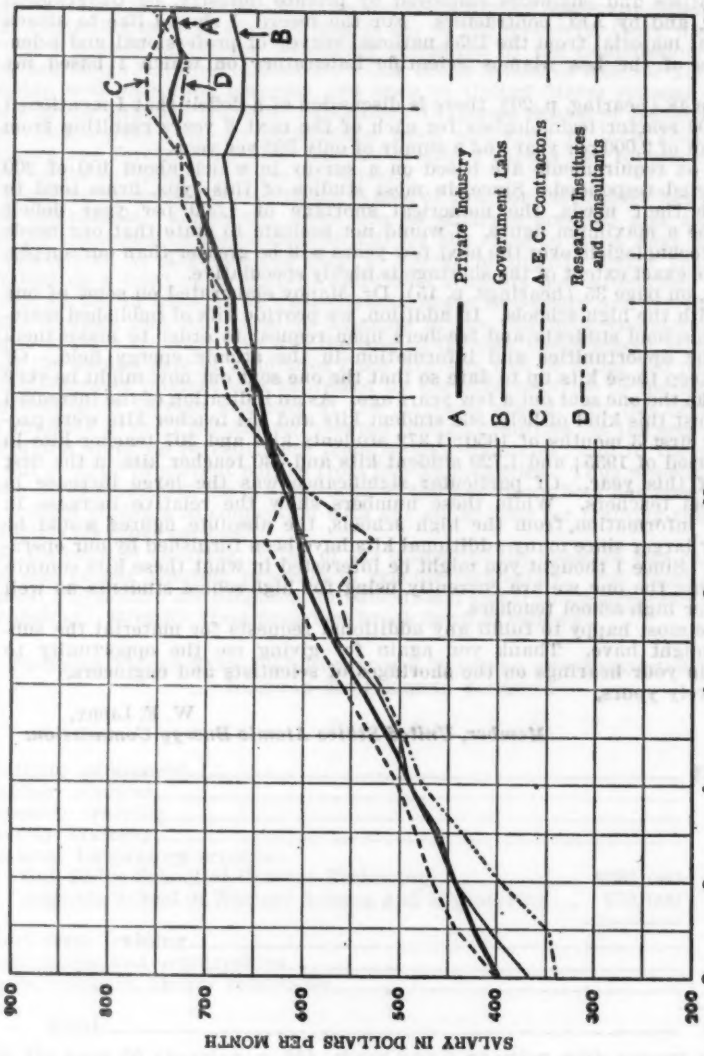


Fig. 3. Comparison of B. S. Salaries by General Field of Employment

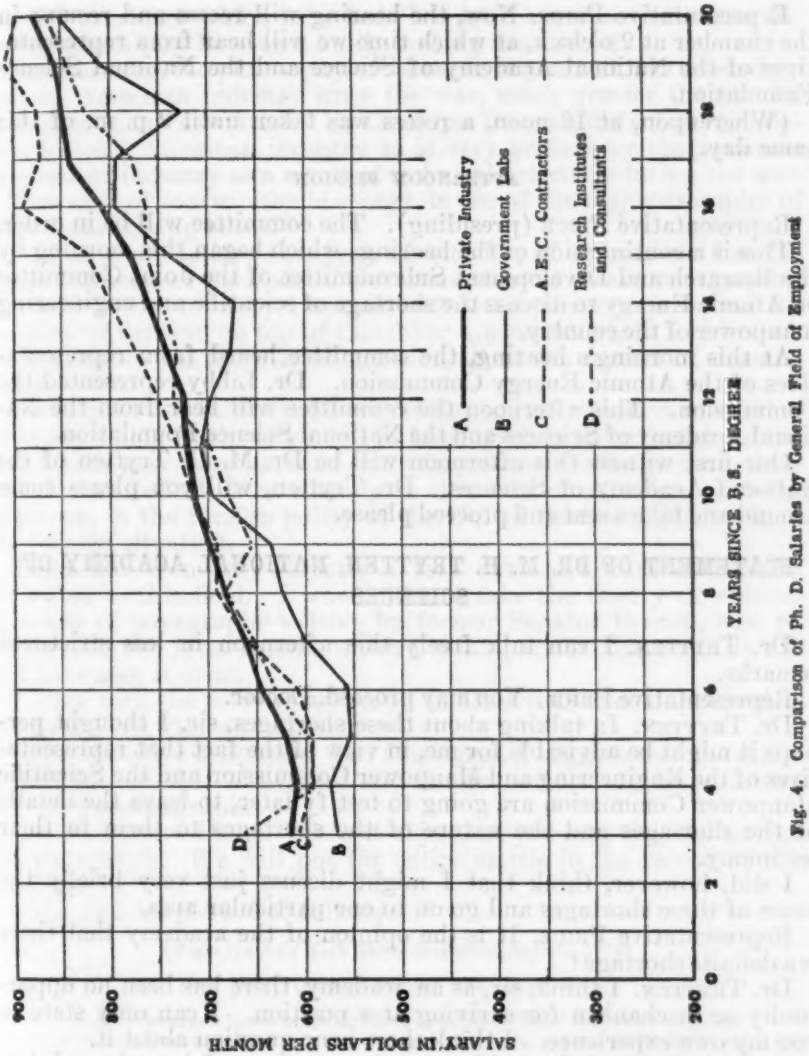


Fig. 4. Comparison of Ph. D. Salaries by General Field of Employment

Fig. 3. Comparison of B. S. Salaries by General Field of Employment

Representative PRICE. Now, the hearing will recess and resume in the chamber at 2 o'clock, at which time we will hear from representatives of the National Academy of Science and the National Science Foundation.

(Whereupon, at 12 noon, a recess was taken until 2 p. m. of this same day.)

AFTERNOON SESSION

Representative PRICE (presiding). The committee will be in order.

This is a continuation of the hearings which began this morning by the Research and Development Subcommittee of the Joint Committee on Atomic Energy to discuss the shortage of scientific and engineering manpower of the country.

At this morning's hearing, the committee heard from representatives of the Atomic Energy Commission. Dr. Libby represented the Commission. This afternoon the committee will hear from the National Academy of Sciences and the National Science Foundation.

Our first witness this afternoon will be Dr. M. H. Trytten of the National Academy of Sciences. Dr. Trytten, will you please come around and take a seat and proceed please.

STATEMENT OF DR. M. H. TRYTTEN, NATIONAL ACADEMY OF SCIENCES

Dr. TRYTTEN. I can talk freely this afternoon in less strictured remarks.

Representative PRICE. You may proceed, Doctor.

Dr. TRYTTEN. In talking about these shortages, sir, I thought perhaps it might be advisable for me, in view of the fact that representatives of the Engineering and Manpower Commission and the Scientific Manpower Commission are going to testify later, to leave the details of the shortages and the nature of the shortages to them in their testimony.

I did, however, think that I might discuss just very briefly the cause of these shortages and go on to one particular area.

Representative PRICE. It is the opinion of the academy that there is a definite shortage?

Dr. TRYTTEN. I think, sir, as an academy, there has been no opportunity or mechanism for arriving at a position. I can only state to you my own experience. I think there is no question about it.

As an individual, I would certainly say that. I have been interested in this for a very long time, as I am sure you know. That would be my statement.

The reason I think so rests on several things which have happened which I think we can all realize if they are only pointed out. World War II, as you know, was a time when there was a tremendous amount of research and development going on in the United States. Practically the whole effort of the scientific and engineering personnel of the country was focused on applied research for military purposes.

The result of that was the development of a great deal of technical information. That information has its economic and its commercial uses, just as much as it has military uses, in most cases. So there has been a tremendous legacy of technical information with definite com-

mercial overtones which have been left by the war to American Industry which they have been busily making the most of.

Furthermore, the philosophy of research, if you will, has taken deep root in American industry since the war, much greater than it did before, in many new areas. So there has been a substantial stimulation to total American industry as is very evident by the economic progress of industry as a result of technical activities during the war.

This and, of course, atomic energy, is one of the major examples of what I am talking about.

Besides that, besides this type of activity, of course, one has the direct influence of the Federal Government in its atomic energy projects and in the military research and development as a second dimension of demand on top of this other dimension which I indicated. So I think to me there is no question about the matter of demand at all.

I did, however, think that I would like to call attention to another situation which I believe we will be hearing more about in the future, and which may pose an even more important challenge than those that I have talked about already in this area of shortage. I refer, of course, to the foreign policy of the United States, if you wish, or the foreign situation.

There has been very recently a very obvious upturn in Russian activities in this field. I would like to take the liberty of reading a couple of paragraphs written by former Senator Benton, who recently returned from Russia, which I think presents this about as well as I have seen it done.

I start with the fourth paragraph in his article which appeared in the New York Times of April 1.

Representative HINSHAW. Mr. Chairman, I suggest that the entire matter be placed in the record and the gentleman may be permitted to read the paragraph.

Representative PRICE. Without objection, you may proceed to read the paragraph. We will put the entire article in the record of this hearing.

(The article referred to follows:)

[From the New York Times magazine, April 1, 1956]

NOW THE "COLD WAR" OF THE CLASSROOMS

Soviet leaders have boasted that Russia's "gold reserve" consists of trained technicians for the future. Here is a challenge flung to our educational system.

By William Benton [1]

Leon Bloy, the French philosopher, once referred to what he called "the good news of damnation." His theory was that none of us might behave as Christians if we were not afraid of perpetual hellfire.

My recent trip to the U. S. S. R. suggests that the Soviet educational system can prove to be the good news of damnation for American education—the spur which may rouse us and propel us toward salvation. If so, this will sustain Arnold Toynbee's thesis that the competition provided by the Soviet system will force us to live up to our own great ideals.

Technical experts form the Soviet Union's "gold reserve," Premier Nikolai Bulganin told the recent Communist Party Congress in Moscow. Further, four

[1] William Benton, a former United States Senator from Connecticut, is the publisher of the Encyclopedia Britannica. He visited the Soviet Union last fall to prepare a report on Communist indoctrination behind the Iron Curtain for the 1956 Britannica Book of the Year.

million new specialists are to be trained before the current 5-Year Plan ends in 1960; this exceeds the combined output of the two previous plans.

Nikita Khrushchev, party chief, shouted at the Burmese in December: "We shall see who has more engineers, the United States or the Soviet Union." He and Bulganin offered to build and staff a technological institute in Rangoon "as a gift to the people of Burma from the people of the Soviet Union."

This is the new "cold war" of the classrooms. And it is very dangerous. I have seen for myself the vast technocratic Sparta that is burgeoning in the U. S. S. R. I have talked to the topmost Soviet educators. I returned convinced that Russia's classrooms and libraries, her laboratories and teaching methods, may threaten us more than her hydrogen bombs or guided missiles to deliver them.

The new propaganda of the Kremlin, emphasizing economic, political, and ideological competition, clearly reveals the long-range Soviet plan—a plan so potent as to make military and political maneuvering seem by comparison tactical and even diversionary. Central to it is the schooling for export of scores of thousands of indoctrinated and capable engineers, scientists, schoolmasters, and technicians of all kinds. These are being trained to help develop the resources of countries outside the present Soviet orbit, and to help convert the world to communism. The advance guard is now in India, to which a technical institute has also been offered; and enticing inducements have recently been advanced to Egypt, Afghanistan and Latin America.

Even more formidable is the spectacular example set for underdeveloped countries by the Soviet Union's mass training for its own industrial needs. For without the present outpouring of trained experts within the U. S. S. R., the sixth 5-Year plan could not promise by 1960 a 60-percent increase in the national product of the U. S. S. R. and a 70-percent step-up in its heavy industry.

If we Americans are now complacent about our own educational problems, at a moment when whole galaxies of our own educational neglect are coming into head-on collision, then we stand in mortal danger of being outwitted, outtalked, outmaneuvered, and outbuilt throughout the world. We are not preparing to cope with the surging flood of youth that looms ahead, demanding to be educated. The Soviet threat may now be the only thing that can shake us out of our sleep-walk—on the educational brink.

What is it that most impresses a foreign observer about the Soviet school system? In less than 40 years, starting with a population about 50 percent illiterate, the Soviets have built a seven-year primary school system rivaling our own in universality, with nearly 100 percent enrollment.

Since World War II, the Soviet secondary school system has mushroomed amazingly. By 1960 the basic 10-year school is to be compulsory everywhere. In spite of acute labor shortages, all children are to be kept in school from 7 to 17. Every Russian youngster is to be given an education—a Communist education of course, but comparable in its high standards of study and learning to an English public school or a French lycée, though without the same emphasis on the humanities.

Further, the U. S. S. R. is on the road to surpassing the U. S. both in the number and percentage of students enrolled in institutions, above the secondary level. Indeed, when high-level extension-correspondence students are included, the Soviet total of 4,300,000 enrolled in 1955 is already 70 percent over our 2,700,000. The Soviet Union offers as much training to every boy and girl as his or her talents and abilities will absorb.

Russian youngsters today go to school 6 days a week, and more hours per day and more weeks per year than ours do. Discipline is strict, study hours are long, the curriculum is demanding, and examinations are severe. At all levels the Soviet students, like European students in general, work much harder than do our American youngsters.

Wearing military-looking uniforms, Soviet children for the first four years of the 10-year school concentrate on reading, writing, arithmetic, and Russian. In the last 6 years, more than 40 percent of their time goes to science and mathematics. During these years they must take algebra, geometry, and trigonometry. Also compulsory are 4 or 5 years of physics, 4 years of chemistry, 2 years of biology, a year of astronomy, and a year of psychology.

Finally, each student is supposed to take 6 years of a foreign language. English, the new language of science, is said to be the favorite in the U. S. S. R. Russian is favored in the satellites.

The contrast with our American secondary school curriculum is startling. Lewis L. Strauss, Chairman of the Atomic Energy Commission, recently told the

Thomas Alva Edison Foundation: "I can learn of no public high school in our country where a student obtains so thorough a preparation in science and mathematics, even if he seeks it—even if he should be a potential Einstein, Edison, Fermi, or Bell." Indeed, last year, for the 28,000 high schools of the United States, we produced only 125 new teachers of physics. I repeat: only 125.

When I was in Moscow last fall Pro-Rector Vovchenko of the University of Moscow told me that, above the 10-year schools, there are now more than 2,000 "tekhnikums." Later I learned that the number probably exceeds 3,500. These have an enrollment of 2½ million students. We in the United States have no parallel for them. They are a kind of vocational college, giving 2½ and 4-year courses. They produce "middle-trained" specialists in scores of fields. I visited a tekhnikum for the coal-mining industry in Kiev, and was astonished at the extent and value of its equipment.

Then there are the 800 institutions of higher Soviet education. Thirty-three of these are universities. The balance are the specialized institutes for doctors, engineers, lawyers, aeronautical experts, electrical specialists, agricultural experts, etc.—all the specialized skills in such demand throughout the world. The universities concentrate largely on the training of teachers, scientists, scholars, and professors. All universities and higher institutions provide 5-year programs, except the pedagogical institutes, which are 4 years, and the medical, which are 6. These top institutions have an estimated enrollment of 1,825,000 students.

Eighty to 90 percent of all students at Soviet higher institutions have been on state scholarships, which included stipends rising slightly from year to year. In February we learned from the Party Congress that beginning this autumn all education is to be free. Every Soviet student can now keep going upward in the Communist world at the state's expense so long as he can make the grades. Indeed, he is pushed, prodded, pressured and enticed to reach the limit of his capacity for training.

The University of Moscow, dominating the city with its gleaming new 33-story central tower dedicated to the sciences, enrolls 23,000 students. The recent investment of 3 billion rubles for this new building, completed in 1953, is astounding by our standards. It is equivalent to at least $150 million. Thus this building costs more than has been spent for the completed physical plant of all but a very few American universities.

It contains 1,900 laboratory rooms. Here work most of the 2,000 professors of the University of Moscow who teach students. Here, too, are the 500 scholars dedicated to research from whom no teaching is expected. Original and creative research is demanded from all 2,500.

Pravda recently reported that 60 million are enrolled in educational courses, including those taking evening and correspondence courses. For most students, of course, graduation from a 10-year school or *tekhnikum* marks the end of formal education. But many continue to struggle and strive for another chance and still another.

This is why one sees teenagers in bookstores buying books on nuclear physics. This is why in the Leningrad library I found every desk occupied in the great science reading room. The silence was absolute; the concentrated zeal of the students was breathtaking. I asked my librarian guide, "Are these university students?" He replied, "Oh, no, the university has its own library; these are workers from the night shifts of the factories; we keep the library open at night for the day-shift workers."

The Soviet educational system has, of course, grave and tragic weaknesses by our standards and goals. There is no academic freedom or tenure for teachers or professors. No criticism of the regime, or of official dogma, is permitted. Classroom discussion is not encouraged. Heavy emphasis is given to rote memorization of texts.

Every advanced student must devote his full time to his specialty except for 10 percent to the study of dialectical materialism and Marxism-Leninism-Stalinism. The student can't change his mind about his profession in midstream; he can't shift. Every graduate must work for 3 years on any assigned job in his specialty.

By our standards, the Soviet system is the training and conditioning of human instruments, rather than the education of human beings. It is designed to sharpen human tools for coming 5-year plans, rather than to develop Soviet youngsters to their highest powers as individuals. It is without human spirit or soul. It is the gospel according to Pavlov.

But I fear the Communists may have found a formula for combining high quality in scientific and technological training and research with an acceptance and obedience in political, economic, philosophical, and moral matters. Whether this formula will hold up over the decades may turn out to be the crucial question of our historical epoch.

The third generation, for whom Lenin said "two whole generations" must be sacrificed, is now coming up. I talked with 40 or 50 key administrators of the current generation, most of them men in their forties. They struck me as men of ability and energy, men who rise to the top in any mobile society. They seemed to me dangerously dedicated men—true believers in communism, and frighteningly ignorant of the West of its system of values, and of its hopes and aspirations.

They went out of their way to talk to me—not about Stalin or even about the present regime—but about the beauties of dialectical materialism and the progress that is being made toward world acceptance of Marxism, Leninism and Stalinism. This last standardizing trio of words seemingly is about to be condensed into Marxism-Leninism, but we shouldn't take encouragement from this recent revelation that there has been latent opposition to Stalin. For many years interviews with intellectual refugees from the Soviet Union have revealed more evidence of unhappiness over "miscarriages" under the Communist system itself. Surprisingly to many, even the refugees from the U. S. S. R. haven't complained too much about the nature of the Communist regime.

Some of the figures I have quoted above were given me by the top Soviet school officials among the men I interviewed. They may exaggerate. But my checks do not prove the figures invalid. I suggest that we would be wise to accept them. Americans have for years scoffed at Soviet claims—only to find that they have outstripped all nations but ourselves in industrial production. The Communists from the earliest days gave up butter for guns; but they gave up meat for education.

How can we meet this new Soviet challenge?

First, we require a generous program of scholarships and fellowships for students of more than ordinary promise who need help. This should be launched at once, both by Government and by private philanthropy.

Our high schools abound with talent worthy of such scholarships. Secretary Folsom of the Department of Health, Education, and Welfare recently cited an estimate that "each year about 60,000 students of high quality drop out of high school before graduation * * * and half of the students in the upper one-fourth of their high school classes do not go on to college." Dael Wolfle, of the American Association for the Advancement of Science, tells us that 150,000 pupils from each age and class who could enter the important specialties fail to go to college. These figures show the tragic waste of our talented youth—our own potential manpower.

The frantic competition for engineers now going on in the United States has been reported on the front pages of The New York Times. Our industries and our defense establishment require at least 45,000 to 50,000 new engineers a year. We graduated 23,000 in 1954 (compared with Russia's 53,000 that year and 63,000 in 1955).

There is also a scramble for physicists, chemists and mathematicians. These shortages have obscured the swelling demand for professional and technical experts in many other fields. At the rate we are growing, we can expect shortages of at least 22,000 physicians and 100,000 nurses by 1960. The shortage of teachers may be the most acute of all.

We in this country must begin to educate more scientists and engineers, and we must learn to do it without turning our schools into *tekhnikums*, or our colleges into factories for producing highly conditioned robots.

I feel that the Federal Government should immediately launch a national competitive scholarship program beginning with as many as 20,000 scholarships a year, each covering 4 years of college. I would increase this as rapidly as the administration of the program, and the absorption capacity of the colleges and universities permitted, to a level of at least 100,000 scholarships a year. To these should be added 20,000 or more graduate fellowships.

Such a program could require a Federal outlay of perhaps $1 billion a year. But Mr. Bulganin's figure of speech about his 'gold reserve" is apt. Trained manpower is like money in the bank. It is our most important national resource.

The second priority is for a program designed to attract and hold the finest instructional corps in the world. That means the development, without delay and on a bold scale, of new incentives for teachers.

Perhaps the second priority provides us with the key question in two parts: First, how can we offer greater incentives to the talented public school and to every teacher who successfully teaches, and to every teacher who successfully seeks self-improvement; and, second, what system of incentives will tempt and hold young prospective teachers of talent? I do not see why we should greatly step up the salaries of hundreds of thousands of teachers who are inferior and who will continue to be inferior. Indeed, one of our national tragedies is that our teachers' colleges do not attract a better caliber of students.

Here again, I fear, we must turn to the Federal Government for leadership. Hundreds of millions of dollars are required at once, to be allocated through State departments of education to communities which undertake to attract and keep uncommonly promising teachers. Further, the Federal Government must help establish a pattern of standards. This will cause a hue and cry about Federal control. We must face up to it.

This brings me to the third requirement, the dilemma of the physical plant. The urgent need is for $3.8 billion a year for the next 10 years if we are to obtain the 950,000 new classrooms required for the public schools.

Because State and local community outlays for school construction are now at a two-billion-dollar-a-year level, leaving a gap of $1.8 billion, the $250 million offered annually by the present administration or even the $400 million of the Kelly bill are far too little.

Fourth, and finally, we must reexamine our teaching methods, and our institutional setup. In the latter category are such questions as the need for more junior colleges, 50 percent of which are today in California.

As to teaching methods, I shall cite only a single example. Our goal of secondary school pupil-teacher ratio has been 25 to 1; in the university it has been 12 or 13 to 1. These goals now seem to be about to vanish. Soon we shall receive the tide of 42 million school children.

We must bring technology to the schools. For example, all plans for new buildings should make it easy for children in Maine and Kansas to learn history and science and arithmetic from the Californian or the Britisher who understands them best and can explain them best through films and educational television. One good teacher, with a couple of aides, can learn how to take care of 200 or 300 pupils—and improve the instruction. This makes it profitable as well as easy greatly to raise salaries in order to attract and hold good teachers.

After 26 years of pioneering effort the classroom film producers of the United States haven't yet put a projector into more than 1 out of every 50 classrooms. By contrast, the U. S. S. R., once it began to use classroom films, has made rapid progress. The goal of a projector in every classroom has not yet been achieved in the U. S. S. R. But at present rates of progress the Soviets will achieve this a decade before the United States has a projector in every school building.

If we compare the Soviet educational system with our own, it is clear that we can lose the race if we continue to waste our potential talent. But it is also clear we cannot win it on our terms on numbers alone. Our best opportunity lies in educating whole men, rather than mere functionaries. Obviously, America must make a larger investment in training for science. At the same time our technical experts must be educated in the liberal arts. They must understand the history and logic of our great traditions of freedom and justice.

Recently, Marion Folsom said, "Education is basic * * * to our collective strength in the cause of world peace."

Soviet Russia may be the first country to develop free and unlimited schooling for all with talent who are willing to work hard. But we in the United States have tended a brighter fire during the last 180 years. That is our dedication to the advancement and perfection of the individual. It should be far more appealing to all mankind if we now begin to do a better job of building the fire to a blaze.

Education is one area where we in America most surely have nothing to lose if we accept the Red gauntlet. Intercontinental competition in education need be no challenge to an arms race or a war. If the Russians goad us to do a better educational job, then we shall only be doing what our own best traditions call for—what we should be doing even if the Soviet Union were to sink suddenly into the sea.

Dr. TRYTTEN. All right. I start with his remarks.

Nikita Khrushchev, party chief, shouted at the Burmese in December: "We shall see who has more engineers, the United States or the Soviet Union."

He and Bulganin offered to build and staff a technological institute in Rangoon as a gift to the people of Burma from the people of the Soviet Union. This is the new cold war of the classrooms, and it is very dangerous.

I have seen for myself the vast technocratic spark that is burgeoning in the U. S. S. R. I have found at the top most Soviet educators. I returned convinced that Russia's classrooms and libraries, her laboratories and teaching methods, may threaten us more than her hydrogen bombs or guided missiles to deliver them.

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Central to it is the schooling for export of scores of thousands of indoctrinated and capable engineers, scientists, schoolmasters, and technicians of all kinds. These are being trained to help develop the resources of countries outside the present Soviet orbit and to help convert the world to communism.

The advance guard is now in India, to which a technical institute has also been offered, and enticing inducements have recently been advanced to Egypt, Afghanistan, and Latin America.

So far, Senator Benton's remarks.

Representative PRICE. I was interested, Dr. Trytten, in your comment in your reply to the committee's letter. You dwelled on this point, and I was very much interested in that point raised in your letter. I hope that you will elaborate.

Dr. TRYTTEN. The evidence, I think, continues to pile up. About 2 weeks ago you may have noticed that Mikoyan, who was then in Burma, March 30 of this year, reiterated this offer that Russia would establish a technical institute in Burma, equip it, and furnish the teachers to train the local teachers until they take over.

So this is to me a challenge which I believe we are going to have to take very seriously and might lead to a dimension of new demand on top of all the other demands which I think might be very real in the future, unless a different interpretation is put on this, and I think those that I have known who have been interested in this have certainly interpreted it in this way.

As to the ability of the Russians to carry through this new type of threat, I think there is also very little question about that. We have in our office very recently published a report on the Russian scientific education system called Soviet Professional Manpower, and printed by the Public Printer.

This has been out now for 4 months. This gives a very complete and comprehensive statement of the Russian training in science and engineering and indicates a very substantial system, indeed, with tremendous emphasis on science and technology from the very first through the elementary and particularly in the secondary schools, and through the universities, with a very large number going through, as far as we can tell, a fairly substantial course of training.

At the secondary school level, for example, almost 50 percent of the curriculum, 47 percent is the present estimate, is devoted to science and mathematics. So the students, by the time they graduate from high school—this, incidentally, also isn't only those going on to do technical work—have 5 years of physics, 5 years of biology, 4 years of chemistry, as well as some geology, some astronomy, and mathematics every year of the 10 years that they are in the elementary and the secondary schools.

This is their preparation for technical work at the university level. At the university level, the work is similarly concentrated, and the numbers flowing out of this school is very great indeed.

At the university level the teaching is in two types of institutions: (1) the technical institute type, such as, for example, our Case Institute, California Institute of Technology, MIT, and Carnegie Institute in this country.

Those institutes turn out engineers and scientists almost wholly and produce the greater number of the graduates. The universities turn out the teachers and the scientists.

Representative HINSHAW. I would like to ask a question along that line, a question on the form of education.

The Russians are supposed to be a great liberal people, according to their teaching. Do they employ what we call the progressive education system or the old-fashioned education system? Do they let a child do what it wants to do, according to its own inclinations, or do they try to really drill it into him?

Dr. TRYTTEN. No, their curriculum and methods are very dictatorial, indeed.

Representative HINSHAW. They don't go for the progressive type of education?

Dr. TRYTTEN. No; I have seen no evidence of that at all. There is very little choice in what they take, and the work is heavy. They bear down on them and tell them what to do, and they have to do it. This, of course, has its drawbacks, as well as its virtues, but it certainly leads to good, hard work on the part of the student.

Representative HINSHAW. I suppose that social studies are not nearly so important, then, in the Soviet schools. I don't mean social studies from the standpoint of political philosophy—because I understand that is considered important, too—but social studies so far as tap dancing, home making, and that sort of thing are concerned are not stressed in those schools, are they?

Dr. TRYTTEN. No. As a matter of fact, in the engineers' schools, only about 7 percent of the curriculum is devoted to fields that you might think of as nonvocational, general studies, and they do lie in the direction of what we might call indoctrination rather than social studies.

There are, of course, socioeconomic curricula which are open to quite a number of persons. This is a recognized branch of the university training and also of the institutes. But it is largely a training in what you might call the mechanics of economics and politics, rather than the underlying philosophy.

The questions of underlying philosophy have been answered.

Representative HINSHAW. In preparation for good party indoctrination, I suspect.

Doctor, you have mentioned in a letter which you addressed to the chairman of the subcommittee on April 2 that it would be desirable, according to your ideas, to inquire into the utilization of scientific personnel by the armed services at all levels to insure that flagrant underutilization of highly essential manpower in uniform does not occur.

I am extremely interested in that subject, as you may have heard, or may be aware, and I would like to question you further, particularly concerning that part of your letter which states that the military

services will need eventually to move toward the establishment of a separate scientific corps, as is done with medical personnel, and a career service established.

I wish you would discuss that aspect of your letter.

Dr. TRYTTEN. You realize, of course, that this is my own personal opinion.

Representative PRICE. I understand, and we are very much interested in your own personal views. To us, you are a very highly intelligent person who has studied this problem at considerable length and has devoted yourself to it.

Dr. TRYTTEN. It is my feeling that the situation in this country at the present time and, as I see it, for quite some time in the future, of high shortages is going to make it necessary to require, as carefully as we can, the utilization of those we have within the services.

It seems to me that if a person of technical skills is really needed, in general he will be in the capacity of a person who must bring the military needs and scientific needs together, a sort of liaison person, or he will need to be a person who must carry out certain scientific work which, because of its nature, has to be completely under the control of the military and therefore, can best be done in uniform.

Otherwise, the technical work is done outside in laboratories and so on. I think of the need here as being relatively not too great. The liaison work may tend to be greater as time goes on, but these, to me, seem to be the places where people with advanced technical training need to be used in the military, and it is my feeling that as time goes on this will become clearer or should become clearer.

So the necessity that I would see is in the services to determine whether, in the first place, a real scientific background is necessary, and if it is necessary, to set the billets up in such a way that this becomes perfectly clear, and people with that type of training can be brought together for them.

To be most effective, it would seem to me necessary that these people have the career opportunities which are available for other personnel in the armed services, other uniformed personnel.

Representative HINSHAW. I might inquire a little bit into that because it has been a matter of some interest to me. I think you know that in many of these military installations, particularly of the Signal Corps, the Ordinance Corps, the Engineer Corps of the Army, and similar installations in the Navy and Air Force, scientific and professional personnel are selected from among the draftees.

They may be privates first class or they might have achieved the rank of corporal if they were extremely good. The complaints that I have received from such personnel in the military service are to the effect that while they are serving out their 2 years just for the purpose of getting those 2 years behind them and for no other purpose at all, they are selected to have military occupational specialty called SPP, which stands for scientific and professional personnel, and they may have achieved the high grade of private first class.

Thereby the military obtain the services of a doctor of philosophy or a master of science or an engineer or technician with 3 years of practical experience for the munificent sum of $75 a month. They say they have a great demand for such things.

Are we to permit the military to fulfill their needs of scientific and professional personnel as privates first class or to recognize those

gentlemen for their character and ability in comparison with the other officer personnel of the military?

I think it is an outrage, myself, that the scientific people of the United States would stand for such a deal. I certainly will bow to any other expressions which may be made on the subject.

Dr. TRYTTEN. You realize what I was talking about earlier was the problem of the officer corps, career officer corps, in the military services. With respect to the enlisted men, of course, that is a different problem. There are certain types of personnel, I am sure, who, if they are taken into the military services to begin with, assuming that they are there, may be rather difficult to use in their basic skills because of the fact that the services may not have use for them.

I suspect that the problem also is one of organization because the services are not organized to make use of these people. Certainly the complaints made of them that I hear are that the enlisted men, when they do go in, are assigned to an organization within the services which is primarily a military organization and consequently the commanders of that want to see them do all of the things that a buck private usually does, I guess, and that may be why they are very poorly utilized.

Representative HINSHAW. I would like to offer the situation from the viewpoint of a young man. I have had a good many of them discuss it with me, and even go on record by writing a letter concerning the situation.

These young men who hope to achieve scientific careers, Dr. Trytten, are in one awful spot these days if they have the eyesight that will pass the military medical test, no flatfeet, and a few other things like that. In other words, the body is warm. When this young man graduates from high school, he has a choice in the matter, and that choice is whether he will break off and serve 2 years of military service under Selective Service and training or whether he will attempt to go on through college.

I think in later years up to now I have been prone to recommend that they stay in school as long as they can, because, of course, by staying in they do not lose proficiency.

If, however, they choose to get the 2 years behind them at the end of high school and go into the service for 2 years, and they come out at the age of approximately 20 and start college, at that point, after 4 years, being 24, 3 more years would make them 27, and still unable to bring in a weekly or monthly paycheck, they look at life rather dismally.

So the chances are that they don't go ahead with their education beyond possibly the 4 years of college. That is just about the limit if they have already served their 2 years. So you have lost to science some high IQ that might have developed into, let us say, an Enrico Fermi or Ernest Lawrence or M. H. Trytten, or whatever.

Suppose, on the other hand, that they decide to go through and they start in as a freshman in college and carry on. They can obtain deferment to go through college, and by a very difficult rigmarole they may obtain further deferment from their local draft board. After all, the draft board may be a bunch of farmers out in the middle of Kansas or Montana or California or New York, but still they can be a bunch of farmers and not interested in scientific pursuits.

At the end of the 4 years they may go on and try for their master's. Under the rules and regulations of Selective Service, so long as they are in the top bracket they may continue, and some of them do continue and become Ph. D.'s. If they do that, they can achieve their doctorate at about age 25 or 26.

Dr. Trytten, scientific people have told me that the most productive period in a young scientist's life, the time at which he is most likely to make scientific discoveries of great note, are between the ages of 25 and 28. Is that not true?

Dr. TRYTTEN. I think I would put it a little earlier than that. I would say 22 and a little later.

Representative HINSHAW. Twenty-two to thirty certainly covers the span of it pretty much, doesn't it?

Dr. TRYTTEN. I think it depends a little on the science, too.

Representative HINSHAW. Exactly. But the records shows that the novel thought or original ideas——

Dr. TRYTTEN. Creative thought.

Representative HINSHAW. Creative span of their life generally has been within that age bracket. Is that so?

Dr. TRYTTEN. Isaac Newton, when he was 27, retired from physics and mathematics into philosophy. He had made his contribution there.

Representative HINSHAW. Quite so. Einstein and the rest of them. At the age of 25 he comes out a Ph. D., but at that age he must separate himself from his normal pursuits and take up a military pursuit as a private or private first class.

If he decides when he is in college to enter the ROTC and takes 4 years of senior ROTC, then he must serve as a Reserve officer, second lieutenant, immediately upon graduation, for 2 years. Is that not true?

Dr. TRYTTEN. I think that is correct.

Representative HINSHAW. Thereby he breaks up his period of education at that point in his life. He breaks 2 years right out of it. I can be mistaken, I suppose, but the military tell me that they can make no selection from among the young ROTC graduates who are becoming second lieutenants as to what duties they will be assigned.

Furthermore, they tell me in the military that the highest duty, the most important duty, that a second lieutenant in the Army has to do is as a platoon leader. That is the prime duty.

This fellow, we will say, has an IQ of 150 or 160, maybe more than that, whatever it may be, which would qualify him to go on in a scientific pursuit, and yet he can obtain nothing but platoon leadership for 2 years. If he goes on to become a doctor of philosophy, then upon his receipt of the degree he can offer himself for induction immediately without further ado, which is probably the best thing he can do, or wait until he is called, which may be within a year, but the best thing that he can get is a private first class.

Down here at Fort Belvoir, for example, they have a whole company of these masters of science and doctors of philosophy in the Corps of Engineers, all of them privates first class, and the Corps of Engineers tell me that they are employing these people at tasks which they believe to be commensurate with their abilities.

That is true, but the duties of a private first class, in contradistinction to the second lieutenant, require what they call fatigue duty,

and that fatigue duty and guard duty which they must do 2 days a week means that for 1 day out of the week they must do kitchen police, KP, and another day out of the week they must do guard duty.

This is for doctors of philosophy who have just graduated and who should be continuing certainly to keep up their profession and whose value to the United States as a whole, in my judgment, is as a doctor of philosophy and not as a private first class.

I would like to know why the scientific profession does not haul up on its hind legs and holler about that situation until it is corrected. Everybody that I have talked to in the scientific profession has admitted that it is a perfectly ghastly situation.

Dr. TRYTTEN. Mr. Hinshaw, I might say that the two organizations that have been organized to deal with problems of this kind directly are going to testify here. Mr. Meyerhoff will testify tomorrow and I have no doubt that he will——

Representative HINSHAW. Mr. Meyerhoff and I are in agreement, and Mr. Meyerhoff and I both testified on a bill before another committee by which we hope that scientific and professional personnel would be excused from military duty and used for what I consider, and I am sure Dr. Meyerhoff considers, to be the much more important duties to the people of the United States, and that is the creative duty, to create something of lasting value.

Dr. TRYTTEN. I think you will find that a very large share of the scientists will agree with you completely there. Why they have not been more vocal is a question. I don't know whether I can answer satisfactorily right now why they have not been more militant on the matter.

Possibly it is because—I am not sure I can answer why.

Representative HINSHAW. I will tell you why it is. It is an inferiority complex which has gotten them because they feel somehow or other that these people who wear the brass are somebody that they should look up to. It is the old college idea of "Here comes the football hero," so we all have to get up and cheer, and yet the fellow with the brains and the ability, the creator of the great weapons of the present day, has to take a back seat.

Representative PRICE. Will you proceed, Dr. Trytten?

Dr. TRYTTEN. Yes. I am not sure how much additional information actually would be useful here. I was talking about the Russian educational system.

Representative PRICE. Yes. Your statement indicates that you feel that the Soviet can use the training of scientific and technological manpower as a considerable weapon economically and politically.

Dr. TRYTTEN. That is true. I think that is what they are planning to do, and I think their capability is that they can do the judging by the numbers of people they are turning out.

I wanted to make only 2 or 3 other points with regard to their system. The first would be the intense nature of their training from the secondary school all the way up through the university, which I did speak about, and the numbers that they are training.

The graduation numbers this June, for example, are to be approximately 72,000 engineers graduating. We are still, as you know, in the twenty thousands. By 1960 they expect to graduate over 100,000 engineers per year in that country. I cannot believe that that tremendous number is intended only for internal use.

I think the intent here is to use them as a supportable surplus, as Mr. Benton indicates in his article.

Representative PRICE. Do the scientific personnel participate in military service in the Soviet Union?

Dr. TRYTTEN. No. Their scientific and engineering personnel are generally exempt. It is the result of a rather peculiar set of circumstances. Their age of military service is about the same as ours, about 18, but because of their 10-year school system, instead of our 12-year system, most bright youngsters can have at least the 1 year at the university before 18 years come along, and having once been accepted and on the job as a student, they are not subject to call until the school year is over.

Then if they are in these critical areas of engineering and sciences, they come under a different type of exemption which covers those fields, and they are then assigned to it for 3 years beyond graduation, which is not military unless it is the sort of thing I was talking about, that is, a specific, organized military activity of a technical nature. They may be assigned to that in uniform, but they are not assigned generally for nontechnical work at all.

So it is fair to state, I think, that as a general rule the graduates and students in these areas of science and technology do not give military service.

Representative HINSHAW. In other words, they obtain 100 percent utilization of their scientists.

Dr. TRYTTEN. They are realists, over there. This is another example of realism.

Representative HINSHAW. That is true of England, also, is it not?

Dr. TRYTTEN. I am not too sure at the moment about England. I had better not say. I am a little hazy about that situation.

I want to make just one other comment about their system and then let that suffice for the moment. It is the relationship between their training in these areas and the secondary schools largely because of the fact that one of our major problems in this country is the strengthening of scientific training in the secondary schools.

We have had trouble holding our teachers——

Representative PRICE. Do you have any recommendations to make along that line for what must be done to correct that situation?

Dr. TRYTTEN. That is quite an order, too. I think the major problems which confront us with respect to secondary schools are several. The first one, I think, is worth commenting on. That is the fact that in many of our secondary schools, in many of our school districts, the school district is so small that the high school itself is very small and it is very difficult to set up an adequate secondary school system in a very small district.

For example, in Iowa I think in that State there are 808 schools which support secondary schools, but they are all very small. Iowa, Nebraska, North and South Dakota, for example, in the farm territory, have about 25 percent of the school districts in the United States. They are all small.

They have that many, although they have only about 4 percent of the students. The result is that you are dealing with a very small school district in most cases and it is difficult to set up an adequate high school under those circumstances.

The result is as you would expect. In Iowa, of their 808 school districts, you have about a quarter of them even offering chemistry, for example. That is what you are up against there.

Representative PRICE. The difficulty there is the fact that you are not stimulating interest in high school students to go on into the scientific field.

Dr. TRYTTEN. That is right.

Representative PRICE. It isn't so much the lack of scientific training at the high school age, but the lack of stimulating interest, is it not?

Dr. TRYTTEN. I think it is both.

Representative PRICE. You say both?

Dr. TRYTTEN. Yes.

Representative PRICE. What necessarily must a secondary school student have in order to qualify to go into the scientific field at the college level?

Dr. TRYTTEN. I can tell you the entrance requirements. I think if a student has a sound mathematics training in high school, 4 years of mathematics, good solid mathematics, he has gone quite a ways toward preparing for college. It would be highly desirable that he have a good strong course in chemistry and one in physics, as well, and he should have to be properly prepared.

Too many of our secondary school people do not have this. The problem, however, is not only what courses he has, but how well they are given. This is where the difficulty arises in many of our schools today. Either because of poorly prepared teachers or the lack of proper attitude on the part of the students or whatever it is, the result is that preparation seems to be inadequate.

For example, I have in my possession information from two of our leading State university engineering schools, not the general admission at all, but the engineering school alone, and in one of these institutions 61 percent of the freshmen in the engineering school were inadequately prepared in mathematics and had to take remedial training.

In the other one, 72 percent had to take remedial training. This, it seems to me, is a measure of the inadequacy of their training before they came out of the secondary school. If that is the case with the preengineering student, I suspect it is worse in the case of some of the other areas.

What is the reason for this? I think the size of the school is one of the things. The student attitude is another. It seems to me the attitude in many of our schools is not too conducive to good training at the present time. The prestige of advance training, and so on, is not as great as it used to be in many cases.

Thirdly, of course, you have the teacher problem, which is one of the major ones. This is one which is actually being attacked rather strenuously by many of our organizations, such as, for example, the American Association for the Advancement of Science and in our own National Academy of Sciences-National Research Council, we have an experiment in progress in that respect.

There is a great deal of ground to be covered there because of the tremendous need for improving the training of the teachers.

Representative HINSHAW. Dr. Trytten, let me make inquiry of you. You touched everything in those three points except the system

of education. I think the system of education supported by the local school boards has a very important bearing on what you are talking about, and perhaps a more important bearing than the three points which you have made.

I may be wrong in that. It seems to me that the preparation for a scientific career, as you said originally, depending as it does on 4 years of good solid mathematics, plus a course in chemistry, a course in physics—I don't know how long that would be, but maybe 1 or 2 years or more, but certainly preparation for high school graduation cannot be brought about if the child or youth who is taking the course is subjected to a system of education which permits him to choose what he wants to do and how much of it he wants to do.

Is the scientific fraternity in a position to discuss the system of education, and is it willing to, or is it loath to discuss it, and why?

Dr. TRYTTEN. I don't know whether I can answer that because there is very little evidence to go on. The interest in this problem on the part of the senior academic people at the university level, as you know, is a very recent thing. Prior to World War II, I had very few experiences with people at the university and college level even inquiring what went on in high schools at all. There was scarcely interest in it. I think this is one of the reasons that we have the situation we have today.

We left the high schools to the people whose profession was education per se, and to people who had less interest in the subject matter fields than they did in the methodology, and so on, of teaching.

Without blaming them whatever for any faults or any lacks or anything else, this is not right on the face of it. People who have subject matter interest should have been interested in this problem in the past.

I think it is only recently that they have begun to be interested in it. My own organization's interest, at least as far as actually doing something, is relatively recent. The AAAS is much older in its interest.

Even so, I would certainly say it is relatively recent. So I think it is only recently that they have gotten into the problem at all and they certainly, as far as I know, have not gotten into the question of educational philosophy or attitude to any great extent.

Representative HINSHAW. That philosophy extends clear back into the grade school, it seems to me.

Dr. TRYTTEN. Yes, it does.

Representative HINSHAW. The necessity for a really good look at it extends to that period of time because that is the formative period in the child's training.

Dr. TRYTTEN. That is right. Certainly between 12 years and 16 years is a very critical time in their training.

Representative HINSHAW. If they are not taught to apply themselves to the task in that period, they probably will not learn, except those who may be so imbued with an idea which they probably have achieved at home or someplace else that they will continue through.

I have seen it myself in the schools of today, where the object of attending school is merely to attend 4 years of high school and get by. They don't have to make any particular grades or do any particular thing.

I wish that you could examine some of the curricula that these children go through.

Dr. TRYTTEN. I noticed in the newspaper reports of the recent meeting at Atlantic City of school principals, school administrators, that one of the subjects of discussion at that meeting was what should or should not be the measure of accomplishment in the school systems.

It did seem rather remarkable that this would be true.

Representative HINSHAW. Just think of that.

Representative PRICE. Will you proceed, Dr. Trytten?

Dr. TRYTTEN. I have very little more to add, sir. I just want to bring in the point of the Russian school system to indicate that I think it is a very formidable program of education which they have and that their aims and objectives seem to be very clear, and this is something that we in America must give very serious thought to. If we do give serious thought to it at all, it will be a substantial factor in the question of the shortage of scientific personnel.

I think, Mr. Chairman, that is the extent of it.

Representative PRICE. Do you think that there should be an established program of any sort to increase the supply of scientific manpower?

Dr. TRYTTEN. Frankly, I am of two minds about that, Mr. Chairman. I am not sure that the additional yield will be sufficient to warrant it unless we can at the same time institute some way or other to insure that the help that we give goes to the people who need it to continue in their work; in other words, to separate out those who would go on anyway from those who would not.

The GI bill, you see, was a very fine thing, but its justification was a little different from this. It did show, it seems to me, that most people, perhaps 4 out of 5 of the people who went on with the GI bill would have gone on had they had the support or not. That is, the additional number was not too great.

If we could develop a scholarship or fellowship system which would in some way pick out those who needed the support to go on and pick out the able ones, I would be definitely for it. I think that would be fine, but if a scholarship or fellowship program were such as merely to pay the educational expenses of all of those above a certain level of ability, I think one, to a large extent, would merely lift the burden onto somebody else's shoulders.

That is my personal feeling about that.

Representative PRICE. Do you have further questions?

Representative HINSHAW. No.

Representative PRICE. Thank you very much, Dr. Trytten. The committee appreciates your assistance and your cooperation.

The next witness is Dr. Harry C. Kelly of the National Science Foundation.

Do you have a prepared statement, Dr. Kelly?

STATEMENT OF DR. HARRY C. KELLY, NATIONAL SCIENCE FOUNDATION

Dr. KELLY. Yes, I would like to make a few comments at the beginning, if I might, Mr. Price.

As the representative of the National Science Foundation, I am pleased to be among those appearing before your committee to discuss

the extremely timely and important topic of scientific and technical personnel. The pace and direction of our future development and safety as a nation may well depend upon our wisdom in dealing with this subject. In order to maintain our technical supremacy we must stress high-level education for an increasing proportion of our people. This education is necessary not only for increased production of corps of highly trained and creative scientists and engineers to advance and maintain our technology, but also to provide a great number of non-scientists in this nuclear technical age with some basic knowledge of the sciences.

We are faced at the present time with undoubted shortages of certain science and engineering specialists which can have serious implications on our economic progress and defense in the near future unless we take corrective measures.

These specialized areas include nuclear engineering, mathematical engineering, guided missiles research and development, electronics, and aeronautics, as examples.

Immediate attention must be paid to this problem.

Other agencies such as the Atomic Energy Commission and the Department of Defense, will undoubtedly report to you on their activities in these specialized areas, and later I should like to report on some of our activities in this regard.

However, in the long range our supply of competent scientists and engineers depends on quality training throughout our educational system and in all fields of science. It is the long-range problem to which I should like chiefly to address myself.

As background to my statement I should like to give, in very broad strokes, the manpower picture as I see it. I believe this background is necessary to my main thesis that our problem is not solely one of increasing the number of scientists and engineers. Rather, the most severe and long-range problem is that of improving the quality of instruction during a period when high school and college enrollments are greatly expanding.

In making this statement I do not intend to imply that we do not need a greater number of scientists and engineers in the future for, as world population expands and our supplies of raw materials decrease, the challenges of and our dependence on science and technology will vastly increase in the future. Rather, my point is that we must emphasize the increasing need for highly trained and qualified scientists and engineers to meet our growing needs—and further training for all of us to be more adaptable to the expanding technical age.

The United States is the leading technical nation in the world, and with appropriate special emphasis we can maintain this technical leadership. This leadership has been gained with about one-half of 1 percent of our population working as scientists and engineers. This small percentage includes our high school and college teachers of science and mathematics. The number of scientists and engineers in our population has grown faster than our population increase. Since 1930 our population and labor force have increased about 35 percent while the number of scientists and engineers has increased by nearly 450 percent and 225 percent respectively.

There was one period in our history between 1950 and 1954, when primarily because of the low birth rate during the depression, there

was an anomaly in this growth pattern. Between these years the number of college graduations steadily declined.

Partly as a result of this decline and partly because of growing military and industrial demands, keen competition by industry and government for these young people resulted. Ability to recruit high school teachers has been particularly affected by this competition, primarily because of the dollar differential.

At present, however, college enrollments are again increasing and today stand at an all-time high, even higher than during the 1949–50 postwar peak. There is every indication that our college enrollments will steadily increase from now on, so that they will at least double by the 1970's and possibly earlier.

The present increased enrollment in college now is due, among other reasons, to the greater percentage of our young people going to college. About 32 percent of the college age group is attending college at present, whereas in 1900, for example, only 4 percent, and in 1930 only 12 percent attended college. This increased percentage of young people going to college, combined with increasing numbers in the group of college age, will put very severe strains on our educational institutions. The postwar population bulge is now approaching our high schools and will reach our colleges some times in the late 1960's.

Merely to emphasize quantity of production of scientists and engineers, then, may be a disservice to our country and to science itself, for this point of view might cause us to be too easily satisfied with solutions which would result only in stepping up the number of poorly trained people in our scientific work force. Moreover, this emphasis on quantity of production must be tempered by careful analysis of the fact that college enrollments are to increase greatly in the relatively near future.

We must recognize also that these increased enrollments compound our difficulties in maintaining and improving the quality of training and that special measures must be devised to insure excellence in training during this period of vastly increased enrollments which lies ahead.

Engineering school enrollments are on the increase, both as to absolute numbers and as a proportion of all college enrollments. From the low point in recent years of about 34,000 entering engineering school for the first time in the fall of 1950, engineering schools reported 72,800 entering freshmen in 1955. First-time enrollments in engineering as a percent of all first-time enrollments have gone from 6.6 percent in 1950 to 10.6 percent in the fall of 1955.

During the late 1940's a decreased percentage of our college population chose engineering courses. This may have been due, at least in part, to faulty extrapolation into the future and widespread publicity about an overproduction of engineers in 1948. The increasing percentage of our youth taking engineering the last few years is at least partly a reflection of our expanding economy and defense and the attendant publicity on the needs for engineers and scientists.

With this background information, I should like to report on some of the activities of the National Science Foundation regarding the training of scientists and engineers.

Our largest program is that of fellowships as one means of giving support to increasing the number of highly qualified scientists and engineers at the earliest possible time. The National Science Founda-

tion has supported since 1952 a fellowship program open for application to any citizen of the United States who has a bachelor's degree in science or engineering or the equivalent.

Since this support is for the postgraduate training of our scientists and engineers, this program has a direct and essentially immediate effect on the supply of well-trained scientists and engineers. The Foundation is presently supporting three different fellowship programs and plans to initiate a fourth during the coming academic year.

The postdoctorate program was also initiated in 1951, and the first 38 fellowships were awarded just 4 years ago this month. This program is directed toward the younger Ph. D.'s in science and engineering who can profit by a year's advanced study and research. This year we awarded 100 postdoctoral fellowships and in addition initiated a senior postdoctorate fellowship program by making awards to 40 scientists and engineers who had held doctoral degrees for a minimum of 5 years and who could profit by taking a year off to refresh their knowledge of science and in some cases broaden their training so that their research competence could be extended into the newly developing interdisciplinary fields of science.

As a reflection of our concern for maintaining and improving the quality of training of scientists as the rate of expansion of our colleges and universities increases, we hope to initiate a science faculty fellowship program this coming fall. This program is primarily designed to give a limited but significant number of college teachers an opportunity to take a year off to bring themselves up to date in recent developments in science so they can more effectively motivate and train young people in science and engineering.

Although the National Science Foundation fellowship program is the largest Federal program, supporting about 2 percent of the graduate students in science, mathematics, and engineering, the total number of students receiving Federal support—directly or indirectly—is about 30 percent of the full-time graduate student enrollment in this country. This support comes through research grants of various agencies of the Government, the National Institutes of Health fellowships, and some support through the GI bill.

Our most rapidly expanding program is that of education in the sciences. Early in our exploratory studies it became apparent that the high school and college teacher of science and mathematics plays a crucial role in motivating and increasing the competence of young people in science and in engineering. It was apparent also that our supply of qualified science and mathematics teachers was dwindling during a period of expanding college enrollments. Our programs in education in the sciences, therefore, have been directed primarily toward increasing the subject matter knowledge of our high school and college teachers of science and mathematics.

Experience shows that we can count heavily on the well-qualified science teacher to capture the imagination of our talented young people, to formulate and teach stimulating courses, and to guide the professional development of able students according to their abilities.

One of our major programs in this area is a program of summer institutes designed to increase the subject-matter knowledge of high schools and college teachers of science and mathematics, especially those remote from the great centers of learning in this country and those who have not had an opportunity to keep up with the recent

advances in the fields of science and mathematics. These summer institutes are conducted by leading scientists known for their scholarship and skill in presentation. The institutes range in duration from 4 to 8 weeks and provide opportunities for informal discussions and conferences between the participating teachers and scientists as well as formal courses and lectures. The foundation began its program by supporting two summer institutes in the summer of 1953. This coming summer we will support 21 in colleges and universities distributed throughout the United States.

With the enthusiastic support shown for this program during our House Appropriation hearing, we hope to expand the number to some 85 institutes for the summer of 1957. This larger program will support about 4,250 high school and college teachers in such a way that attendance will not be at a financial sacrifice to poorly paid teachers.

It is recognized that in order to motivate more of our young people toward teaching careers, we must increase their opportunity for intellectual refreshment and provide adequate salaries and prestige in their communities. Because the summertime is traditional free time for our high-school and college teachers, we hope to expand this program to be able to take advantage of these conditions. At the same time the program may not only increase the subject matter knowledge of our teachers but also increase their prestige by enabling them to become more closely associated with the community of science and provide stipends sufficient at least to compete with the summer nonprofessional work which most of them are forced to undertake in order to make their incomes even reasonably adequate.

Because of the critical nature of the training problem and the need for excellence in training, the foundation this coming year will support 2 academic year institutes designed with 2 purposes in mind. Frst, to give encouragement to our colleges and universities to set up special year-long programs in science and mathematics, designed especially for high-school teachers of science and mathematics. And, second, to give support to at least a limited number of our high-school teachers of science and mathematics to become substantially more proficient in their subject matter specialties.

We hope to expand this program in 1957 to about 15 colleges and universities distributed throughout the United States.

On a more limited scale we are supporting various other pilot programs. For example, a visiting scientist program operated by the various scientific societies. It is designed to give colleges and high schools, especially those removed from research centers, an opportunity of profiting by 1 or 2 weeks visits by eminent scientists who can discuss with both students and faculties new developments in their field.

We are also supporting a project administered by the American Association for the Advancement of Science, a circulating library of carefully selected books of science and mathematics. These books will go to a selected group of small high schools as an experiment, where students do not have full exposure to typical high-school science courses.

During the period of rapid expansion of our high schools, experimental sciences are likely to suffer the most because of the expense involved in equipping laboratories with adequate equipment. As an experiment to compensate for this and to give adequate opportunity

for our young people to become familiar with experimental apparatus, the foundation is supporting a traveling science demonstration program this coming year.

The foundation has given special consideration to the training of personnel in the science disciplines that have the most severely acute shortages and has studied those areas in cooperation with other Federal agencies. In cooperation with the Atomic Energy Commisison, for example, the foundation is supporting a summer institute at Argonne National Laboratory for the purpose of instructing professors of engineering in the subject of nuclear-energy. Sixty professors from engineering colleges will attend this institute and plans are under consideration for a second institute of this kind at Brookhaven National Laboratory. One of the purposes of these institutes is to train teachers who can establish centers of training throughout the United States.

The foundation is also cooperating with the Atomic Energy Commission in the support of 3 summer institutes in radiobiology for high-school teachers, to be located in three different parts of the United States.

The foundation also has under current consideration other proposals such as post-doctoral internship program for the training of applied mathematicians.

The foundation is continuing its study to develop new pilot programs worthy of support and to gain insight into methods of early identification of scientific talent and the process leading to the choice of a career field.

In all these programs it is recognized that the motivation and training of our young people is a joint responsibility of our scientists and educators alike, and we hope that all of our programs will be supported enthusiastically by both groups.

The foundation further recognizes that education of our youth is a national responsibility, and it is traditionally a concern of local and State groups. We hope to devise other programs as pilot programs to stimulate support from local, State, industrial and nonfederal agencies. One of these efforts resulted in the formation of a National Committee for the Development of Scientists and Engineers. Some time ago the President recognizing that we must draw on all the resources of the Nation for the solution of this problem, established a special Cabinet level committee to make an intensive study of the ways in which the Federal Government could cooperate with State and local governments and private citizens' groups to develop a course of action to deal with this situation. This committee was chaired by the Director of Defense Mobilization and consisted of the Secretaries of Commerce, Labor, Health, Education, and Welfare, the Chairman of the Atomic Energy Commission, the Assistant Secretary of Defense for Manpower, and the Director of the National Science Foundation.

The Cabinet group recognized that the problem of motivating our young people was primarily a local one, dependent in large measure upon the efforts of the leaders in the field of education and upon the professional societies and organizations.

It was also clear to the group that if the public were to be aroused to do something about the situation, industry and labor must assist in telling the story and aiding in constructive action.

The Cabinet group recommended therefore that the President appoint a National Committee for the Development of Scientists and Engineers. It recommended further that he appoint to this committee the heads of a number of major organizations in fields of education, science, engineering, and the humanities, together with representatives of management, labor, and of State and local governments.

On the third of this month the President appointed such a committee with Dr. Howard L. Bevis, president of Ohio State University as chairman. The President in his letter to the chairman, Dr. Bevis, set out the charter of the committee by expressing the hope that the committee would (1) Assist the Federal Government in identifying the problems associated with the development of more highly qualified scientists and engineers, (2) Enlist the cooperation of all interested individuals and groups in analyzing the problem and developing programs to deal with it, and to take the lead in coordination of interested organizations outside the Federal Government, (3) Make available to all interested organizations information on effective ways of overcoming the obstacles to the training of more qualified scientists and engineers, and to (4) Publicize the problem and possible solutions in order to stimulate widespread public understanding and support.

The National Science Foundation is supplying staff assistance to the committee and will support its efforts to stimulate increased non-Federal support to the problem and of maintaining our technical strength.

In summary, I should like to state that with increasing world population and decreasing supplies of raw materials, the United States and most nations of the world are recognizing our increasing dependence on basic research and technology to help alleviate our growing problem. With increasing economic and military completion, the United States is recognizing that in order to maintain our technical supremacy, special and wise efforts must be made to give high quality training to a greater proportion of our young people. This is the long-term project.

In the new field of atomic fallout, automation, and powered homes, all of us need some training in the sciences to be better adaptable to this new age. In preparing for these new challenges and responsibilities, mere members will not be enough. We must emphasize excellence in training. Expanding high school and college enrollments compound the difficulties our schools have in maintaining the necessary quality of training. Traditionally, and I believe wisely, we have depended on local and State school systems and private and State Colleges to educate our young people. Our Federal efforts should be designed to assist these institutions in increasing their competence and effectiveness in meeting the great problems associated with our expanding population and new technical needs.

In developing special programs to meet the presently recognized acute shortage areas in technological training, we must bear in mind the possible effects on the long-term best interests of our country. The need for basic fundamental research and trained basic researchers is for all fields of science and technology, for it is impossible to predict which particular research idea will have the most profound effect on the later technical age.

For this research, time and resources for quiet reflection and free experimentation are needed. Too much Federal or any central direction or control could possibly lead to a kind of Maginot line in technology. Our teachers are the key to identifying, motivating, and wisely training our young people. We must make special efforts to increase the number of competent and well-trained people by making the teaching field more attractive by increasing salaries, allowing time for intellectual refreshment, and keeping abreast in particular fields, thereby helping to increase their prestige and effectiveness.

I thank you, Mr. Price.

Representative PRICE. Thank you, Dr. Kelly.

Doctor, several pages back you referred to the pattern that regular educational institutions had the function of training technical manpower. Then you suggested that we had a national responsibility in the Government to assist to meet the problem as we grow year by year. Do you have any suggestion of what kind of assistance the Government might propose or offer?

Dr. KELLY. The kind of assistance that we propose we have proposed through our budget. One of the most promising areas to me is to take advantage of the free summertime of our teachers and of some of our colleges really to utilize this time for helping bring our teachers up to date in science and mathematics, to give them some financial support during this time of study to compensate for not taking a summer job of tending a gas station or the like, and also to bring them closer to the community of scholars and scientists, so they will be members of the community of science and not off on their own.

Representative PRICE. When you refer to teaching you are thinking not only of university professors, but you go to the secondary level.

Dr. KELLY. Yes, sir; our programs are expanding at the secondary level. We began first these programs only with college teachers.

Representative PRICE. How extensive is this program at the high-school level?

Dr. KELLY. We will have about 15 summer institutes for high-school teachers of science and mathematics.

Representative PRICE. Where are your institutes usually held?

Dr. KELLY. I have a list of them here which I might read. We try to distribute them by fields of science and geographically. I will read through the list. There are 21 of them:

Alabama College, Argonne National Laboratory, American University, University of Arkansas, Cornell University, Indiana University (2 institutes), Iowa State Teachers College, Marshall College, University of Michigan, Montana State College, Oak Ridge, Tenn. (2 institutes), Oregon State College, Penn State University, University of Rochester, University of Utah, Connecticut Wesleyan University, Williams College, Wisconsin State College, University of Wyoming.

Representative PRICE. I wonder if you could give me some idea of your foundation's appraisal of the laboratory facilities first at the university level and then at the high-school level throughout the country, what they think about it, what their strengths and weaknesses might be.

Dr. KELLY. I can think of only weaknesses. Also it will probably get worse before it will get better. Especially with our expanding

elementary, secondary, and college enrollments, this is going to be very expensive to local and State communities.

Science is an expensive course to teach, much more expensive than some of the social sciences or English or languages. It requires equipment. So in a tight budget experimental science is likely to suffer the most. This is especially true in smaller towns with small high schools which cannot afford special laboratory equipment.

So I would say that the problem of laboratories and equipment will be an increasing problem in the future.

Representative PRICE. Do you have a close enough survey of high schools throughout the country to have any picture of whether or not they are providing new laboratory facilities in most of the new construction in the country or whether they are neglecting laboratory facilities?

Dr. KELLY. No, sir; I have no such survey. I believe the Office of Education has made such a study, but I am not familiar with any figures which came up on that.

Representative PRICE. Any questions, Mr. Hinshaw?

Representative HINSHAW. Dr. Kelly, you heard our discussion of the training program at Argonne and Oak Ridge?

Dr. KELLY. No, sir; I wasn't here during that part of the testimony.

Representative HINSHAW. I believe your testimony indicated that the National Science Foundation was engaged in part in that undertaking at Argonne and Oak Ridge.

Dr. KELLY. Yes.

Representative HINSHAW. What part of it do you participate in?

Dr. KELLY. We supply the money primarily for stipends of the teachers to go to these institutes.

Representative HINSHAW. For the teachers to attend the institute or for the teachers to teach in the institute?

Dr. KELLY. Partly both. I am sure about all the money for the stipends of the teachers who are coming as students, and the money for the teachers of the teachers is partly contributed by AEC local staff and partly by the National Science Foundation.

Representative HINSHAW. In other words, it is not only a grant of education but they get paid for it, too, is that right?

Dr. KELLY. Yes; in order to get our teachers to go to school during the summer they must make great sacrifices themselves and they must be given stipends to compensate for the salaries which they would have lost during the summer.

Representative HINSHAW. That is something new to me. I thought teachers were on a vacation for 3 months during the summer and they were expected to make the stipend the rest of the year and spread it over the summer. What do you mean, employment in the summer?

Dr. KELLY. I think the most significant cause is that of the high-school teacher, whose salaries are not competitive with most other occupations. Almost all of our male teachers who have families are forced to work during the summer to make up for their low incomes.

Representative HINSHAW. Of course I am not aware of the situation, and it is quite possible that you are more than correct.

Dr. KELLY. We can see some reflection of this in the experience we had with our summer institutes. The first 2 years we paid a very low stipend, and at a few of the institutes we noticed that the great majority of the teachers were old-maid spinsters who did not have a

family to support. We inquired into this. The reason we were not getting a higher proportion of men teachers was because they just could not afford to come even with the stipend we paid.

Representative PRICE. This is to your institution?

Dr. KELLY. Yes.

Representative HINSHAW. Argonne and Oak Ridge?

Dr. KELLY. I was talking in general about all of them, especially the high-school ones. For the Argonne and Oak Ridge ones, these are engineering professors and most of them also have other work which gives them some income during the summer. It is not as severe in the colleges and universities, but it is still an important problem in our colleges and universities, most severe in our high schools.

Representative HINSHAW. Dr. Kelly, I don't know what we are coming to in our educational system. It has been brought to my attention on several occasions in the past that the work the American technical colleges are performing is supported upward of 50 to 60 percent by Federal grants for Federal projects. Then in addition to that, you have to pay the students some sort of grant or scholarship. It looks to me as though it is becoming mostly a Federal support business, this business of higher education in technical colleges. Why don't we just take them over and be done with it. I would like to know your ideas.

Dr. KELLY. I am sure your reason is that above all we must maintain the freedom and independence of our colleges and universities in the country.

Representative HINSHAW. How free is a college 70 percent supported by Federal grants?

Dr. KELLY. I am not sure that there is a significant number of colleges and universities in the United States that receive this much support. I am not a good witness on that.

Representative HINSHAW. I am speaking of the technical colleges now. Of course the colleges of the arts are not in that classification at all.

Dr. KELLY. You would not consider the State institutions in this class?

Representative HINSHAW. I can use the term contracts as well—grants, contracts and otherwise, research contracts, Defense Establishment contracts, agriculture and even the National Science Foundation and the National Institutes of Health and all the rest of it put together.

You mentioned a while ago the list of Federal agencies which were contributing to Federal education.

Dr. KELLY. I am not your best witness on this, sir. I don't have the figures on the percentage of support colleges and universities are receiving from the Federal Government, but there is a problem which I think is one of the main interests of your committee, that of maintaining technical supremacy. We have on the one hand, an expression of need by the Federal Government, and the additional need, that we give all the support we can that can be used wisely by our colleges and universities to increase their competence, versus the other side, as you point out, of overbalancing their books by Federal support. This is a decision which we must make.

Representative PRICE. Dr. Kelly, you said one of our problems was to maintain technical supremacy. From our observation both of our

picture here and the picture overseas of other countries can you see any threat to our ability to maintain our technical supremacy at the present time?

Dr. KELLY. I would like to give a careful answer to that careful question. I have no knowledge of classified information. I just read newspapers and talk with scientists who have come back from abroad.

Representative PRICE. Just on the basis of information which is available to you.

Dr. KELLY. I would say the United States is still the technical leader in the world, and we can maintain this position. It would take special effort for us to maintain it. We know from reading the newspapers and other conversations that almost all nations of the world are making special efforts to improve their technical position. So we must do so also.

Representative PRICE. Has your organization any information which it has gathered on its own as to the efforts of other nations in the scientific field?

Dr. KELLY. No. The report which Dr. Trytten has given to you is information which we have also. We have no further written information on what other nations are doing.

Representative PRICE. I do not have a copy of your statement before us and it was a little difficult to follow it and remember it.

Dr. KELLY. I am sorry, I finished it just before I came up here.

Representative PRICE. We understand that. In your statement you do enumerate your specific programs of the National Science Foundation, backing up your efforts as an organization to stimulate interest in scientific training?

Dr. KELLY. Yes, sir.

Representative PRICE. Chief among those, as I get it, is the summer institute.

Dr. KELLY. The emphasis on the teacher; yes, sir.

Representative PRICE. How many people would you say participate in that program?

Dr. KELLY. This summer there will be about 1,200 high-school teachers.

Representative PRICE. How many of those would you say would be from secondary schools?

Dr. KELLY. That is the figure I gave you for high schools.

Representative PRICE. 1,200 from high schools?

Dr. KELLY. Yes, sir.

Representative HINSHAW. I am somewhat concerned, Doctor, that such a high proportion of our top scientists in the United States who have contirbuted so much to the atomic-energy program and generally to the scientific aspects of our Government, the Defense Establishment and otherwise, are among the foreign born. I have not seen figures which would give the percentage, but from just a rough calculation in my own mind it would be upward of 30 percent anyway. If you take the very tiptop, creme de la creme of the whole thing, it would run maybe to 60 or 70 percent. Is there something about the foreign educational systems which can be identified which would tend to produce such people or is it a matter of blood or a matter of genetics, let's say, in certain groups or races or whatever, which would lead to that condition?

Dr. KELLY. I don't know if you want me to answer the last. As nearly as we can tell, it is the result of the social atmosphere and conditions which we can develop conductive to scholarly advancement. I mentioned this a little bit in my presentation of the need for time, in addition to money for equipment and the like, and freedom of experimentation in the sciences. I believe your statement is correct that in the past we have depended a great deal on European science, but I also believe that there are indications that we are in this country also building up support of basic research and we are developing young people who are competent to advance knowledge in the scientific field here.

Representative HINSHAW. I have noticed that there is much more, let's say social recognition, given to persons in the scientific and technical groups in Europe than there is here. For instance, in Germany I remember in times long gone by "Herr Doktor Professur," and so forth. They would give him all of his titles in introducing him. Here "Herr Doktur" and "Professur" likes to be called "Mister." He doesn't want to be singled out as Herr Doktur or anything of the sort.

Is there any way you can think of to help build that prestige so people will desire to achieve it?

Dr. KELLY. I was interested in your comment and Dr. Trytten's comments on this. As I interpret the scientific community, they would not like to be isolated in that way. We like to be considered as part of the community in the United States. The awards of the scholar are learning something new and the opportunity of discussing things with other scholars. I believe that giving this prestige with Herr Doktur or Professur would not be welcome here or would not really contribute much toward our development in science.

Representative HINSHAW. I was thinking of the prestige which also comes from income.

Dr. KELLY. Now you are talking in a different language. One of the first lessons I learned in coming with the National Science Foundation is that a scientist is an economic man and he behaves in some statistics like any other man. He is influenced by money, and salary. This is one of the motivations of a career and one of the motivations for prestige as well. I agree with you.

Representative HINSHAW. On top of that comes the thought that the scientific and technical professions have to fight for their place in the economic system and they don't seem to be willing to do it. They will mention they can't afford to work for a certain university when some other university is offering them a doctor's chair plus a smaller stipend to be sure, but the honors are greater. I don't think that should persist.

Dr. KELLY. I think this a strange phenomenon. I am not an economist. I am a physicist. I don't understand this. When the needs of the country are so great, they must be reflected ultimately in increased salaries for scientists, and engineers, when the need is expressed in demand they probably will be raised, I don't know.

Representative HINSHAW. I see that General Electric program on television every Sunday, Progress Is Our Most Important Product. Where do they get the progress if it isn't from the scientists and engineers? Yet that is the most important product they have. It is about time that the scientists and engineers step forward and take a

bow, is it not? If their most important product is progress. Progress is a result of careful thought and study and experiment and so forth, brainpower, in other words, applied to, let us say, mechanical, chemical and learning tools of all kinds. Somebody is being very backward about taking the bows and probably the money, too.

Dr. KELLY. This I hope will be one of the results of your hearings. These should be supported not solely by the scientists and engineers because they would be considered perhaps a special interest group in raising the issue too loud.

Representative HINSHAW. They are too modest entirely. They might be considered a special interest group. They are a special interest group. If they don't take a special interest in themselves, I would like to know who will. The other fellow is willing to hire them for just as little money as they can get them for.

Dr. KELLY. I agree with increasing the salaries of scientists and engineers, but how this can come about by accelerating the process of reflection of the supply demand, I don't know. I don't know how that should be done except by convincing industry.

Representative HINSHAW. Of course the process is going on now, perhaps rapidly enough. On the other hand all you need to do is to take a look at the New York Times financial section and find 5 or 6 pages of display advertising seeking the services of scientists and engineers, to the point where a recent convention of electronics engineers in New York was considered to be a great hiring hall for the electronics and electrical people of the United States. There were some 40,000 supposed to show up there and, as was expected, probably 15,000 changed jobs while they were there, and for higher pay. On the other hand, that is not the general run of the scientific profession. The higher pay is coming about through the present existing shortage.

Dr. KELLY. There is some indication, especially in the new industries recently developed from science, nuclear engineering, electronics, and so on.

Representative HINSHAW. But that very thing is posing a terrific problem to the prestige of school districts and universities because, as industries raise their sights, so far as its offering to scientists, technicians, and engineers, correspondingly the local governments and the governing bodies of universities must raise theirs also, which means that they must raise their income because they have to have income with which to pay salaries. When it comes to income for those people it is generally tax money. So when you come right down to it, it is a case of educating the average man that the scientist and engineer is deserving of a higher pay scale in society, is it not?

Dr. KELLY. Yes; especially regarding researchers as such, and high school and college teachers. I think it is especially true of them.

Representative HINSHAW. That is right, even in the farm school districts and remote school districts, those people must want to see to it that their children are better educated than they have been in the past in order to keep up with progress in the modern world.

Dr. KELLY. I heartily agree, sir.

Representative PRICE. Doctor, have you any idea how many scholarships go to technical students through the industrial program that we have? There are 2 or 3 large companies which sponsor scholarship

programs of some sort. Do you have any idea how many there are?

Dr. KELLY. These are undergraduate scholarships?

Representative PRICE. Yes.

Dr. KELLY. We do have that, but I don't believe I have it here. If you like I can report to the committee later on the number that we know about. Of course that changes daily. More and more industries are becoming interested in this.

Representative PRICE. I recognize that, and you in your statement recognize the shortage of scientific and technical manpower in specific fields. Do you care to make any recommendation of a personal nature, what you think might be done about helping to solve this problem?

Dr. KELLY. In particular the scholarship problem?

Representative PRICE. Not necessarily the scholarship problem. The committee is not considering any particular legislation. We are here more to bring this important matter to the attention of the public more than anything else. If some helpful solution should develop, well and good.

Dr. KELLY. I think Mr. Hinshaw expressed it better than I did, that the problem is the importance of training our young people and the importance of recognizing that this is a local community problem and a State problem, and the problem then is to convince the taxpayers of the town or State that this is an important problem and they must give increased support to this in the future. This is in some ways a publiciy problem. I think one of the interests of your committee is to draw attention to the special areas of need. It is one of the areas to which we hope to call the attention of this new national committee which is being formed, a sort of citizens committee, to see whether they can stimulate support at the local levels for this problem.

I think the closer relations we can get between our scientists and educators the better off we will be. In some cases it may be a little bit delicate, but I am sure that both groups are really concerned about the welfare of this country and concerned about developing programs which can increase our competence. So any program which can be developed to have the scientific community and the educational community working together in increasing the competence of our teachers, especially high school teachers, the better off we will be.

Representative PRICE. Does your organization make any contract with local educational boards in the matter of the suggestion of curricula to promote more interest in scientific subjects?

Dr. KELLY. No, sir. Our relationship on curriculum, which is a kind of touchy subject because of the possibility of Federal influence, is that in this area we stimulate studies between local groups and scientific groups. That is, if we give support to the studies of anything involving curriculum we make it to a representative scientific society who will work with the educators groups or local groups who will work in developing curriculum. We give support primarily to societies.

Representative PRICE. Doctor, do you have some further comment you would like to make?

Dr. KELLY. No. I thank you for letting me come.

Representative PRICE. We appreciate your presentation, which will be very helpful to the committee. I think we all agree this is an important subject. The purpose of our committee is to bring attention to the problem in the hope that those who do share the responsibility

for this matter may eventually evolve some solution to the problem.

Dr. KELLY. Thank you.

Representative PRICE. Mr. Thomas T. Hildebrandt is our final witness today. Mr. Hildebrandt.

STATEMENT OF THOMAS T. HILDEBRANDT, MANAGER, WASHINGTON OFFICE, ELECTRONIC TECHNICAL INSTITUTE, INGLEWOOD, CALIF.

Mr. HILDEBRANDT. I am Thomas T. Hildebrandt, representing the Electronic Technical Institute of Los Angeles. We are engaged to a great degree in training military personnel. I thought Congressman Hinshaw might be interested in some of the information that we obtained in that field. I don't think it is necessary for me to go over the broader problems, but in our work in training the military I have been on a recent tour through——

Representative PRICE. Under contract with the Defense Establishment?

Mr. HILDEBRANDT. Yes, in electronics. We are training Air National Guardsmen, for instance, in the science of electronics. I have recently completed a tour from Maine to Florida of the National Guard units of those States, including Montgomery, Ala., and Georgia, and they are considering a program similar to what the Air National Guard is doing.

The thing that impressed me in that tour in relation to this problem was training these scientific technicians, and so on. Of course, as you know, every engineer requires about 10 technicians, so the requirement for technicians numerically is much greater than it is for electronic engineers. I will confine my observations to electronic engineers.

The lack of physical facilities in universities has been brought out in a good deal of the testimony, and the lack of teachers has been brought out, so I don't need to go into that. There is one possible method of immediate relief in the utilization of the National Guard armories. We have about 2,000 National Guard armories in the United States. A great percentage of the time they are not occupied. They are occupied only on drill nights, and so on. A large portion of the time at the average National Guard armory there is very little activity going on. I recognize that the National Guard's function is that of defense of the country and that it should not be basically an educational institution, of course. But because of the immediacy of the situation and the urgency of it, it seemed to me that the National Guard armories could be utilized.

Congressman, you hit the nail on the head when you said there is a lot of talent in the Army and the services that could be utilized to a much greater degree. I have encountered that personally in a good many military establishments. Very well qualified men do things which of course they think are proper things for them to do because again they go back to the fundamental that the purpose is the defense of the country, not education. That is the difference of opinion.

It seems to me that the utilization of the National Guard armories, of which we have 2,000, and I think a good many more are in process of construction, is desirable, coupled with a method of home study.

We have a shortage of teachers which everyone recognizes, but we educate many by means of home study. I think the International Correspondence School of Scranton is an outstanding example of that. The universities with their extension courses are utilizing home study. So I think there could be a greater utilization of home study of the sciences, particularly in electronics, where this is thoroughly practical and is being done—we are doing it all over the world from our school—utilizing the facilities of the armories as classrooms. They have drill floors, classrooms, and offices that are used only on drill nights, very, very sparsely. That is one method of helping to relieve this situation in a very immediate manner.

I want to make it clear that this is entirely my own idea. I have not even discussed this with any of the adjutants general of the States that I have called on. In making these trips that thought comes to me so vividly. Here is a great deal of space just going to waste—space, heat, light, facilities. It would not require much in the way of equipment to make them centers of home study courses in the sciences utilizing either the local teachers on extra duty or men in the military, lots of whom I know are eminently qualified to act as teachers.

That is all I wanted to contribute.

Representative HINSHAW. Mr. Hildebrandt, this is an interesting thought. In the atomic energy field, in which we are particularly interested, there has to be a certain amount of equipment. Of course there is a great deal of mere classroom materials also. You will recall Dr. Libby of the AEC pointed out yesterday that the equipment requirement was in the neighborhood of $250,000 for 1 equipment kit to teach reactor technology, for example. That has to be installed. There has to be a proper set of conditions surrounding the equipment. That is simply a kit. That is not a reactor. It has a noncritical amount of material, and so on. I would assume that the armories would be a fine thing for teaching some subjects all right.

Mr. HILDEBRANDT. I am thinking of this in the elementary stages, Congressman, where you have to start these men. Young men can't get to college. They come out of service and take a job. They belong to the guard. I think that is very laudable. There are a lot of fine men in the guard. But because of their economic condition they cannot afford even a home study course. They can't take the time to go to the service schools. The guard doesn't have money enough to send a lot of them to the service schools. They would all like to send more to the service schools, but they complain that they don't have money enough to do it.

Representative HINSHAW. Let me ask you, in your particular institute do you take the enlisted men in the Armed Forces who are going to operate the radios, radars and whatnot, and teach them the maintenance techniques?

Mr. HILDEBRANDT. Basical electronics, sir. We start them with ordinary simple static electricity.

Representative HINSHAW. What degree of educational background do they have to have?

Mr. HILDEBRANDT. Do they have educational background? We would like them to have at least 2 years of high school because of the math requirements. We have found over a period of years in teaching the military that we have to develop a special mathematics course which they are now using, which we did not require for our students

at the Institute or our normal home study students who were taking it all over the world. The military level of mathematics attainment had to be brought up. So we developed a special course in mathematics. We teach them mathematics and fundamental electronics.

Representative HINSHAW. Basically, then, you are teaching electronics, utilization and maintenance, is that so?

Mr. HILDEBRANDT. As electronic technicians. We don't go beyond electronic technicians. We don't give degrees because we don't teach the other subjects. We don't find that demand. We find the demand is for electronic technicians. Our school at Inglewood, of course, like every other school, has crews in from the aircraft companies and the research and development people watching the students from almost the day they start their course and offer them jobs. Every one of them has three or four jobs waiting for him as soon as he graduates. That is no problem.

Representative HINSHAW. Mr. Chairman, for some time I have had a bill in your committee, which would institute an advance training course for technicians in the Army through private schools or high schools and make a contribution on the part of the Government toward their training, in the belief that the training period takes too much out of the military service that a person must give to his country and that that training could be just as well supplied, if not better supplied, during the period of education in the last 2 years of high school or shortly thereafter. I think it would be a net savings to our Government in terms of the service that would be performed and the degree of service which would be performed by those who were volunteers or inductees into the military service.

That is a quite different subject, I believe, from the subject at hand, which has to do with atomic energy, but nevertheless it is a subject that we are considering.

Mr. HILDEBRANDT. Doesn't it cover the whole broad subject of this great lack of trained scientists and technicians, which is a national problem?

Representative HINSHAW. It is a national problem, but it is a little bit different.

Representative HINSHAW. It is different from the particular approach of this particular hearing.

Mr. HILDEBRANDT. I didn't want to be out of order.

Representative PRICE. You are not out of order. We are glad to have you make your statement.

Mr. HILDEBRANDT. I see in the guard facilities a tremendous amount of plant which is just not being utilized.

Representative HINSHAW. The technical training schools around the aircraft schools, for example, one run by Major Mosely at Glendale, and one out at I believe Pomona, another at Santa Maria and so forth, are all technical institutes of a sort and could be more broadly utilized by the Armed Forces in order to save the period of enlistment for actual services, if possible.

Mr. HILDEBRANDT. I think you have one problem in that certain groups in the Army want the men for one purpose and another group want them for another purpose. How to determine whether they can afford to send a man to a service school like Fort Monmouth and Great Lakes and schools of that caliber. It gets down to a question of money, the way I understand it.

Representative HINSHAW. The military say, "We want to train them ourselves. We have our own training schools," and so forth, so they waste 2 years of the enlistment period in training, whereas if they were trained in high schools before they ever went into the service they would get 6 full years of 4 full years depending upon the period of enlistment, and that degree of service. To that end a very much lesser number of personnel would be required by the armed services to support the same program of defense. There is no question about that at all.

Mr. HILDEBRANDT. I think we are not utilizing a great mass of young people who can not afford to go to college, and who can not afford to take home study courses, but they can devote the time, and they have the time. I think you can get a lot of instructors and utilize the present facilities that they have. To my mind it is as simple as that.

Again, I want to make clear this is entirely my own idea.

Representative PRICE. Thank you very much, Mr. Hildebrandt. We appreciate your appearing.

That will conclude the hearing this afternoon. The committee will meet again tomorrow at 10 o'clock.

(Whereupon, at 4: 10 p. m., Tuesday, April 17, 1956, the committee was recessed, to reconvene at 10 o'clock Wednesday, April 18, 1956.)

SHORTAGE OF SCIENTIFIC AND ENGINEERING MANPOWER

WEDNESDAY, APRIL 18, 1956

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
SUBCOMMITTEE ON RESEARCH AND DEVELOPMENT,
Washington, D. C.

The subcommittee met at 10 a. m., pursuant to notice, in the Old Supreme Court Chamber of the Capitol, Hon. Melvin Price (chairman of the subcommittee) presiding.

Present: Representatives Price (presiding), Durham, Hinshaw, and Van Zandt, and Senator Gore.

Present also: George E. Brown, Jr., of the staff of the Joint Committe on Atomic Energy.

REPRESENTATIVE PRICE: The subcommittee will be in order.

This is a session of the Research and Development Subcommittee which has been authorized by the full committee of the Joint Committee on Atomic Energy, to hear testimony on the shortage of scientific and engineering manpower, particularly as it affects the atomic energy program.

Our first witness this morning will be Dr. Howard Meyerhoff, of the Scientific Manpower Commission.

Would you proceed to make any statement that you care to, to the subcommittee.

STATEMENT OF DR. HOWARD MEYERHOFF, EXECUTIVE DIRECTOR OF THE SCIENTIFIC MANPOWER COMMISSION

Dr. MEYERHOFF. I am Howard Meyerhoff, a geologist by profession, and, as you have noted, the executive director of the Scientific Manpower Commission, which is an organization representing the 10 major scientific groups of the country, including such large societies as the American Chemical Society, the American Institute of Physics, and the American Institute of Biological Sciences; the Federation of American Societies for Experimental Biology, the American Psychological Association, and the American Geological Institute; also the Policy Committee for Mathematics, the Policy Committee for Scientific Agricultural Societies, and the American Association for the Advancement of Science which I understand will testify through Dr. Wolflee, and more recently, the American Astronomical Society.

I think I can say we do represent the entire scientific profession of the Nation with regard to manpower, and our special charge is to deal with the subject of manpower.

I was asked to direct the activities of this organization when it started in business 3 years ago, early in 1953.

In presenting testimony to you this morning, I though that I might start with the points on which I think there is general agreement, so that you can pick me up if there is not.

First of all, I think we all are agreed that there is a shortage. In the engineering field, which will be covered by my colleagues in the Engineering Manpower Commission next Wednesday, the shortage annually is very serious at the moment because we are graduating only about 25,000 or 26,000 engineers this June, and the need for engineers is currently up to about 40,000.

Representative VAN ZANDT. You said 26,000 were graduating?

Dr. MEYERHOFF. The forecast for June of this year is 26,000.

Representative VAN ZANDT. How does that compare with the overall need?

Dr. MEYERHOFF. A very conservatively estimated need of 40,000. Mr. Endicott of Northwestern University has estimated the demand for 1956 to be up 47 percent, which would carry the figure up to 45,000, Mr. Van Zandt, but that, of course, is based upon a presurvey of the needs of 160 companies and it may or may not be highly accurate. At least it is an index of a greater current demand than in any year in the past since Korea.

Representative VAN ZANDT. Is that exclusive of Government?

Dr. MEYERHOFF. Yes.

Representative VAN ZANDT. Then the deficit would be greater if we added the needs of the Government.

Dr. MEYERHOFF. And if you add the growing need, also, for teachers in our colleges of engineering, it would be enhanced by another figure of, say, 2 or 3 percent.

Representative VAN ZANDT. Is it not true that we are graduating about 50 percent of what we actually need.

Dr. MEYERHOFF. I am afraid that that is true, sir.

Representative PRICE. We estimated this year there would probably be about 35,000 graduates, which is a little over last year, and in 1954, the first professional degrees were conferred on 22,000.

Dr. MEYERHOFF. That was the low point.

Representative PRICE. That was the very low point, particularly when we take it in relation to the peak after the peak mark of 52,732, which was about 1950. That was due to the GI bill of rights.

Dr. MEYERHOFF. That is right. In the fields of science, the shortage is not so great numerically, but it is just as acute. Of course, it is differential. In the field of biology, for example, the shortage is chiefly in the specialties, and notably in a few of the agricultural and medical specialities. In general biology, I can detect no serious shortage at all yet. There will be in the teacher category as our college enrollments rise. But at the moment, that situation is pretty much in balance.

On the other hand, when we turn to the two fields of mathematics and physics, we discover there the shortages are alarmingly acute. In physics, for example, at the recent placement service of the American Institute of Physics there were something like 1,780 plus job openings, and there were some companies that did not specify how many openings they had, so you cannot determine the number above 1,780. There were 309 applicants for jobs, and all but 8 of them were em-

ployed. So you can see the men involved were merely shopping around for better positions, and actually there was almost no available personnel except 8 unemployed physicists, plus the prospective graduates at various degree levels this June.

Representative VAN ZANDT. Did you say all but 8 of them were students?

Dr. MEYERHOFF. No, all but 8 of them were employed or were students; 8 were unemployed, sir, and those were the only ones really free to take new positions without vacating old ones. In the field of mathematics, we have no set of statistics quite as revealing as that, but nonetheless we know that there were over 100 college and university teaching positions vacant during the past year for lack of personnel. In the other fields of science, such as my own, geology, there is a rather serious shortage in certain areas, not in others. The oil industry, for example, has undertaken a program of expansion that has been going on for 3 years, and there we find an urgent need for personnel, particularly for foreign service. There is a need that is difficult to fill because so many of our young graduates have military obligations, and therefore they are not good people to send out of the country for the period of 2 or 3 years that is feasible and necessary in the case of a foreign assignment.

I will not take up the individual fields 1 by 1, but I do think it important to place before you the fact that the shortage is differential.

Representative PRICE. Will you point out the field in which you in your figures indicated the most serious shortage exists?

Dr. MEYERHOFF. That is physics. I would say there that we have a cumulative shortage of close to 3,000 physicists, with some substitution, of course, from mechanical and other engineering fields.

Substitution is not quite as good as the original article, especially where research is needed and where trained physicists are better equipped to carry on the research than is the mechanical or the electrical engineer.

The point I made a moment ago I would like to stress, and that is that between the years 1955 and 1956, according to Endicott, and also according to the placement services of the American Chemical Society, and of the American Institute of Physics, the demand for scientists and engineers has risen between 45 and 50 percent. That was in 1 year. Even with increased graduations, markedly in engineering, markedly in geology, and very moderately in chemistry and in physics, we are going to be, if anything, more seriously short, even with our new graduating class, than we were a year ago.

To what extent these shortages are cumulative we do not know. Somehow we have a knack of getting along without the personnel we cannot get. But we must grant that it sometimes involves the sacrifice of research, the passing up of Government contracts which are of the utmost importance in the public, and particularly in the military, interest. We recognize the fact that there is an attrition, that we lose the need for some of the people simply because the work is not done.

Representative VAN ZANDT. There is no substitute for the trained physicist.

Dr. MEYERHOFF. There is not, no, sir.

The shortage, I might say, is not due to a decline in the number of people taking science. There was that decline between 1950 and

1954, which was largely a reflection of the dropoff in the number of GI's studying in the field of engineering and science. If we rule out that GI bulge, we find that there has been a steady increase in the number of scientists and engineers over the years; but, on the other hand, the increase has not been commensurate with the demand. So the big feature in the shortage is the rapidly rising demand, rather than any decline in the numbers of people who are registered in engineering and science.

Representative PRICE. Do you feel that that demand is increasing at a more raid rate than the number of students are increasing?

Dr. MEYERHOFF. Yes, sir. I do not know what the figure is worth, but in my job I have to play with figures.

Representative PRICE. We have the figures somewhere here in our study.

Dr. MEYERHOFF. This is another one, I think. I did talk it over with Harris Collingwood, who discussed this report with me. Dr. Steelman, you will recall, projected the gross national product and indicated that it should increase to match the welfare and advancement of the country, about 3 percent per year. We have tried to take the figures of personnel needed to maintain that 3 percent rise and it looks to us as if the figure for engineering and scientific personnel would have to increase about 4½ to 5½ percent, let us say an average of 5 percent, in order to maintain that rate of progress.

The actual figures of increase are substantially below that from the low base of 1954. In short, we cannot see before 1965 or thereabouts any rise in the number of graduating scientists and engineers at various degree levels that will be commensurate with the need.

Representative PRICE. Of course, we are talking now only about the normal times, and we are not even thinking about what would happen if we got into trouble and there would be a demand for full mobilization of manpower.

Dr. MEYERHOFF. That is correct. May I say that I am serving as a member, by invitation of Arthur Flemming, of the Committee on Specialized Personnel. In a special subcommittee of which I was a member we went into the problem of need in an emergency. There is no hope whatever of meeting that stepped-up demand, even for something short of war.

Representative VAN ZANDT. Doctor, why is it that the ODM, and the educational institutions of the country permitted themeselves to drop behind? Was any effort made to keep abreast of the demand, and if so what were the problems?

Dr. MEYERHOFF. Well, sir, I hesitate to go on record on some of the things that I would like to say, but in part, it was stupidity. For example, not recognizing the very obvious fact that the 1950 graduations were a swollen group, thanks to the GI bill of rights—and I mean thanks to it, because it certainly helped us tremendously in recruiting people for these technical fields—not recognizing that the 1950 bulge was a temporary factor, professional groups failed completely to look at the freshmen enrollments of 1950, which were at an alltime low. One reason for that was we had used up the GI reserve, and the other was the drop in the birthrate during the thirties. The word went out in several fields, I am ashamed to say, including my own, that there was an apparent surplus of personnel in engineering, geology, and elsewhere, and student counselors were advised to lay off promoting

the fields of science and engineering. That word got around and it was given currency by the Bureau of Labor Statistics in good faith. It was not particularly stupid on their part, they took it over from the professions, but you know, sir, that every single scientist and engineer was employed at the time of graduation in 1950, so that there was no surplus when the Korean war broke out just a few days following June graduations.

Representative PRICE. Not only were they employed, but most of them had 6 to 10 offers of employment.

Dr. MEYERHOFF. At that time, I think it was a little less, Mr. Chairman.

Representative PRICE. But at the present time it is pretty close to that, and probably better than that now.

Dr. MEYERHOFF. As soon as Korea broke out, that was the fact, there were half a dozen offers, and now, of course, some of our men are getting 12 or 14 offers of employment.

Representative PRICE. Also you have to take into consideration that the industry is different today than it was 20 years ago. It is more technical today.

Dr. MEYERHOFF. That is correct, just as the military is. I have it on authority of one of the members of the Atomic Energy Commission that they and industry could use 40,000 scientists and engineers in the next 2 years in order to utilize all the technical information they have with regard to atomic energy.

Representative PRICE. The Atomic Energy Commission testified here yesterday that they require about 2,000 new reactor technologists per year, and they have been able to recruit only about 25 percent of that demand. A lot of that has to do with industry going into the program, and industry is probably meeting the same problem.

Dr. MEYERHOFF. Very definitely, and in fact in our Commission—and we do not deal with engineers—we get, I would say, half a dozen inquiries a month: Do I "know anywhere where atomic scientists or atomic engineers can be obtained?" That is, by piracy, if necessary. You can see the desperation that faces both the Government and industry in this particular field, with a shortage of electrical and mechanical and other types of engineers, and physicists, and mathematicians.

Representative PRICE. Dr. Meyerhoff, getting back to my statement, I think what I said should have been directed more to the 1955 record among graduates. Of 420 who graduated in June from Carnegie Tech, it was reported that they had offers of from 6 to 10 jobs per student. Another company official said there were 400 competing companies to divide the graduates of MIT. So it indicates that the demand is steadily increasing and becoming greater each year.

Dr. MEYERHOFF. If I may introduce a note of levity, in a small engineering college with 110 graduates, 127 recruiters came in, and 6 of the recruiters did not return to home base. They started working on each other, with a little success, although that was only 5 percent, you see.

Representative VAN ZANDT. Doctor, I have another question. I have found in the past several years that the physicists we do have say their services are now being employed not by 1 or 2 corporations, or agencies of Government, but by many of them. In other words,

they are employed as consultants by many industries or Government agencies. What effect does that have on their efficiency as a teacher?

Dr. MEYERHOFF. Well, for the most part, it raises the devil with them. The consulting is done in large part by the university teachers, and I must say that teaching suffers because of it. It is too much of a strain. There are a few, however, who devote themselves entirely to consulting, who have staffs to carry it on and there my statement would not apply. But in the teaching profession, there is very definitely a loss to the student who is endeavoring to learn the subject from the highest personnel that the college possesses.

Representative VAN ZANDT. In other words, we not only have a deficit in the number of physicists employed as teachers, but their efficiency as teachers is impaired because of the strain placed upon them.

Dr. MEYERHOFF. Yes, I would say that is a very tempered statement of the fact. We are working them to the hilt. Perhaps it is a little too much for the good of their health and the good of their mental processes.

I thought, Mr. Chairman, that perhaps we should review some of the factors creating the shortage. I am sure the man who follows me on this morning's hearing, Mr. Carleton of the National Science Teachers Association, will take care of the high school situation more competently than I. I suspect, however, that he may be reticent about one question that arose yesterday in the hearing. There is a great deal currently being done to recruit more and better teachers. That was one of the subjects, of course, in the White House Conference. It has been occupying the attention of school superintendents and of many educational organizations for some time. Even the scientific and professional societies are now so concerned about getting high school teachers who are competent to teach that much attention is being given to it, although we cannot say the situation is under control.

Mr. Carleton may feel more reticent than I need be about the question of curriculum that arose yesterday—educational philosophy, if you wish to call it that. There we must face the fact that with the changes in the numbers of youngsters going to high school there has necessarily been a change in the philosophy of education, because many more must be educated. Their I. Q. is somewhat lower than 30 or 60 years ago, when most of the high school work was designed to train people for college.

The result has been the introduction of a great many electives so that the student might choose rather widely from a number of different courses, and in his choice omit such things as mathematics, even a certain amount of English beyond the elementary courses, and sciences. He may stop with a course in general science and never be exposed to physics or chemistry. The result has been a marked drop in the proportion of students taking physics and chemistry courses, and a marked drop also in the proportion who are completing sufficient mathematics to enable them to enter engineering careers.

Yesterday Dr. Trytten mentioned the case of two engineering schools in which one found 61 percent and the other 72 percent of the entering students unable to take the freshman mathematics course. We have other figures in the Manpower Commission, which throw the average right in between those two figures. One-third of the students entering engineering schools are qualified to go ahead with

the mathematics required for their work. One-third have had the mathematics in high school but did not have good enough instruction to carry the freshman mathematics in engineering schools, and another third did not have sufficient mathematics to meet the entrance requirements but were permitted to enter because they had the I. Q. in other respects.

Representative PRICE. As I understood it, those were students who were sort of charting their course along engineering lines, even when they were in high school, and they planned to attend engineering schools.

Dr. MEYERHOFF. That is correct.

Represetative PRICE. When you get to the average school enrollment, I think the percentage of those who take mathematics courses are something like about 20 percent, is that not about the figure in the usual high school?

Dr. MEYERHOFF. It depends on which field of mathematics you take. John Lattimore of George Washington University is completing a study and, though I have not seen his final figures, I understand it is higher in algebra but drops sharply in geometry and trigonometry. There has been a marked drop, which he has charted, I think, with a high degree of accuracy. It is an appalling drop, and the same is true in physics and in chemistry. He is not a scientist, so he was interested in other fields. He finds that the requirement of English, which we all need to express ourselves since we are dealing with people and facts that must be explained, is the same way.

Representative PRICE. If a young man did not make up his mind about the first year he entered high school he was going to be an engineer, he was not very well equipped at the end of 4 years to suddenly decide he would like to go to an engineering school, would he?

Dr. MEYERHOFF. He could do it but it would take him time to make up the subjects that he lost or failed to take. I think that one of our slogans at the present time, in the Manpower Commission, is worth repeating, and that is, "Do not close your door to opportunity—take mathematics so that you can elect an engineering or scientific career." That is good advice, I think, to get passed along into the high schools of the country and to the counselors of the country, and we are trying to do it.

I would like to deal with two other subjects in this field of factors creating shortage. I think the fact of the low birth rate of the depression years is well known, so that I will not go into that. But yesterday, the question of military service and its effect upon the shortage came up and Dr. Trytten said that I would probably cover some aspects of this, and that my colleague, Dr. Davison, who will testify next Wednesday, will cover even more.

I would like to say that, just as a statistical proposition, if you take 2 years of our students out of scientific work, you are losing a 2-year supply. That is evident. We are waiting that much longer for their services, and the serious part of it is that there is considerable attrition. By the time a student finishes 2 years of military service, he feels that he wants to earn a living or he wants to get married, or both. Just how to calculate the loss of interest that takes place among young men we do not know. I can say this: If a man is really burned up to be an engineer or a scientist, he will be one, but on the other hand, if

he is on the fence and he has the capabilities, we may lose him in this 2-year period. That is the value, of course, of this new 6-months training program that was introduced into Public Law 305. We do not yet know how that will affect the situation, because only now is it being applied by Selective Service and we, as yet, have no results on which to base a judgment. So we are watching that with very considerable interest, because it will shorten the period of immobilization of our scientific talent from 24 months to 6 months.

Representative PRICE. Has the Scientific Manpower Commission ever made any definite recommendations in that military phase on the scientific manpower situation?

Dr. MEYERHOFF. Yes, we supported what is now Public Law 305, the Reserve Act of 1955.

Representative PRICE. You mean the 6-months training program.

Dr. MEYERHOFF. Yes, sir.

Representative PRICE. Prior to that, though, in the handling of scientific students under Selective Service, did you ever make any recommendations in that regard?

Dr. MEYERHOFF. Yes, sir, continually. We supported a bill, an amendment to the Draft Act that was introduced by Senator Flanders to reinstate selection in our Draft Act. As you know, that went out the window shortly after the Korean incident ended, and everyone was taken regardless of essentiality in industry or in teaching, or regardless of the status that he had attained in his graduate work. We found, for example, graduate students being yanked out of courses within a matter of weeks of the completion of their work for a degree. That, may I say, has stopped, although we face now a new danger in that respect. The regulations which have been promulgated by the President and then converted into operations bulletins by General Hershey, and by the Department of Defense, contain several features which are having bad results that we might have foreseen but did not.

I will give you one, because a case came in this morning before I came over to these hearings. Let me review the directive or the operations bulletin that recently was issued by General Hershey.

He has placed an order of availability upon men in the manpower pool for military service. Those who are 19 to 25 are the most available. That is without children. Then next are fathers in that age group. Least available are men who have for reasons of deferment attained age 26 and are between age 26 and 35 in which they still retain legislative liability. They are in the less available group.

However, this order that has been established has spurred a great many local boards into picking up men who are 25, and who are unmarried, and not fathers. They will soon cross the line of 26 and become less available in the manpower pool for military service. Within the past 2 months, I guess that at least 20 or 25 cases of men in graduate school, approaching the completion of their work, have come to my attention because they have been lifted by their boards or are about to be lifted by their boards and have their careers interrupted.

Industry is also beginning to feel the pinch, because essential men who have been deferred to age 25 are now being picked up also by the local boards which, in their zeal to get their man before he becomes 26 are losing their perspective on the essentiality of certain people.

Representative VAN ZANDT. Is it not true, Doctor, that the Selective Service adopted a policy months ago, whereby a board was established in each State?

Dr. MEYERHOFF. Yes, sir.

Representative VAN ZANDT. The purpose was to screen these individuals. Has it proved of any assistance in any way?

Dr. MEYERHOFF. That is going to prove of tremendous assistance in screening men into the 6-month program, Mr. Van Zandt, but quite a few of these cases I speak of are not being referred to those boards at all.

Representative VAN ZANDT. Why is that?

Dr. MEYERHOFF. I do not know. I am trying to find out. It is a new situation, and I have taken up this one case as well as the general case, with Colonel Prosser of Selective Service this morning. I have already taken it up with General Hershey of the Selective Service System. As yet there has been no chance, you see, to judge how bad this drain upon the 25- and 24-year-old group will be, but it can stop a great many people short in their careers in our colleges and universities, because that is a very critical age, when many of them are just on the verge of getting a doctor of philosophy, or just on the verge of getting a master's degree.

Repersentative PRICE. Dr. Meyerhoff, do you have any comment to make with regard to the utilization of scientific and engineering manpower within the armed services?

Dr. MEYERHOFF. Yes, sir; I presume that you want me to be rather candid in these hearings, and I would not hesitate, and I have not hesitated, to say the same things to appropriate members of the Department of Defense.

In the Committee on Specialized Personnel of the ODM, we have a subcommittee under Mr. Cavanaugh of the Engineering Manpower Commission trying to assess the utilization of engineers and scientists in the military, and particularly in the Army, in the scientific and professional personnel program. There is naturally a tendency to whitewash what goes on on the part of Army officials, and may I say, they have reason to. The S. and P. P. program has been substantially improved since its introduction, and I do wish to give the Department of Defense, and particularly the Department of the Army, a great deal of credit for that improvement. But may we face one rather homely fact, and that is that only part of our military has adapted itself to our technological age. So we find that some of the installations in which these men are working are under what a few of them, to use their own term, call spit-and-polish brass, where it is deemed more important for these men to carry on the activities of privates, K. P. and guard duty, and other nonrelated or nontechnological tasks than it is for them to carry on in their work. We had the horrendous instance of an instructor pulled out of a class which he was instructing, at the orders of his commanding officer, to carry on some menial task that was unrelated to the business of instruction. At several installations, excellent use is made of the men. Every report I get from Redstone Arsenal, for example, is tops. On the other hand, I can give you specific instances where the emphasis placed upon the routine duties of privates, regardless of whether the man is a doctor of philosophy or not, seems to take precedence over their importance as scientists.

I also feel—and this is a personal feeling which I have not yet had

an opportunity to pass on to the proper authorities in the Army, although I have talked about it liberally, particularly with Generals Sturgis and Smith of the Engineering Corps—that I think there is also an opportunity to utilize many more scientists in important work. Take my own field, for example. The mobility of equipment is a function of slope, kinds of soil, the saturation of that soil with rain or frost. Yet the Army is contracting for studies of that kind outside the Department of Defense and at the same time not utilizing the 2,000 or more geologists they have in the service to carry out the experimentation with mobile equipment to see just how it behaves in different kinds of terrains and different kinds of weather conditions. They use the excellent services of the military unit of the United States Geological Survey to determine supplies of water, and to determine foundation problems, but they have got just as good geologists in the service that they could use for that purpose.

You may hear them say, "We cannot do much with a man in 2 years." I seriously object to that statement because in the colleges and the universities we can train bachelors to be masters in 2 years' time. In fact, some of them in less time. We can bring masters up to the doctor of philosophy level within that period of time, and for the military to contend that they cannot get a great deal of technological service out of these highly trained men in the 2 years' period or the 18 months when they are available for the specialized work is ridiculous. They simply do not know the facts.

That is about as much as I wish to say. I think that my colleague, Dr. Davidson, will talk more about the ROTC. Suppose I turn to one other pending factor that may bear very seriously upon the shortage.

About 2 months ago, Dean Whittemore of the Virginia Polytechnic Institute was asked to undertake a survey of the land grant colleges and State universities to see how their facilities for the training of engineers was holding up. Dean Whittemore reported about 3 weeks ago, and it was a spot-check survey and not a complete one. He finds that already our colleges of engineering in the public domain and the State colleges and land-grant colleges, are reaching capacity for students in engineering. Many of them are already considering cutting off their enrollment at the point to which they can accommodate students in their laboratory facilities, buildings, and dormitories.

Here we are faced with the rather appalling problem of working on our young people at the high school level to persuade them to go into engineering and scientific careers if they have the mentality and the interest to do it, but they will very quickly be faced by the lack of facilities for increased enrollments in our schools of higher education. It is a most frightening situation and probably one that the committee can deal with.

Representative VAN ZANDT. Is there a very definite shortage of facilities at the present time?

Dr. MEYERHOFF. I can only talk statistically, Mr. Van Zandt. But the actual college enrollment at the present time exceeds the GI enrollment of 1949–50. That is not yet the fact in the schools of engineering and the departments of science. I think there is still room for about 12 more percent before we reach that GI level. Of course, that is differentially spread. Some institutions are hit already, and others have not yet reached full capacity. But that was only a temporary situation, and now we are facing a permanent one. I would

say, in answer to your question, that the evidence suggests that we are short of space, short of equipment. And that is why I think that that is a place where this committee might well give its attention; that is, to the college level and the teaching program. The staffing problem is another manpower matter of very serious import.

But nonetheless, the physical faciilties, I think, can be utilized to attract more personnel because with good research facilities available a great many men will have the balance swung in favor of teaching instead of in favor of industrial work.

Representative VAN ZANDT. We have a dual problem, as I see it. We not only lack manpower, but in addition we lack facilities.

Dr. MEYERHOFF. We are up to that point; yes, sir.

I would, if I am not talking too long, Mr. Chairman—and you can stop me any time you want to.

Representative PRICE. If you have a statement you care to make, the committee would be glad to hear you.

Dr. MEYERHOFF. I would like to review very briefly the attacks on the problem and perhaps point out 1 or 2 of these things where I think that we are not doing enough and need to do a great deal more quickly. In regard to recruitment of high-school students, there is a great deal of current activity. Industry is putting out a great many attractive pamphlets, even general pamphlets like the General Electric one on Why Study Mathematics? That has been distributed by the millions of copies, and it is an excellent job.

Our technical societies are also getting out career pamphlets, and placing them in the hands of teachers and student counsellors. For example, at the March 14 to 17 meeting of the National Science Teachers Association, we ran a booth in which we distributed free guidance literature. We disposed of several thousand copies and we could have disposed of many more if we had had them but we did not realize there would be such a demand. They covered the fields of engineering and science. There were industrial pamphlets, as well as pamphlets gotten out by the scientific societies, and we found that the teachers who were present avidly grabbed everything they could in order to make the best possible use of it with their students.

We feel that recruitment lags, perhaps, because we do not know enough about what motivates students, what makes them tick, and why they pick a specific career. We can usually trace the inspiration back to a person, but whether is it the parent, the teacher, the guidance counselor, or a friend or Dutch uncle, we do not know. We need to know a great deal more about that, perhaps through some well-directed research.

At least, the problem of recruitment, may I say, is being worked on very actively. In the high schools, as I have already indicated, we have not worked at all consistently on the curriculum, and for a number of different reasons. Dr. Trytten mentioned one yesterday; namely, that the college teacher or university teacher has thought it was not his business, and he has hesitated to meddle with something in the secondary schools. He has been a little too indifferent about it. Now, however, he finds the students ill-prepared, and he is getting worried, and perhaps that question will receive attention. But it is worthy of note that it did not feature among the subjects dealt with in the White House Conference on Education.

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Representative VAN ZANDT. Are you familiar with the forum that was held, last fall, in Iowa, by the Iowa Cornell University, when they invited to the college campus hundreds of high-school students who were interested? The AEC, I understand, filled the panel with speakers, and resulted in the forum being highly successful. Have you any report on that forum?

Dr. MEYERHOFF. I do not. Dean Hartzel of that institution gave me some information about it, but not enough to talk intelligently, Mr. Van Zandt.

There have been, may I say, a number of different meetings for different purposes, of teachers, of students, and so on, but notably teachers. I received notice of one recently and I am trying to remember where it was. I think it was Westminster College at Fulton, Mo., which just recently held a third annual conference on the exceptional student and what to do with the exceptional student. Efforts of that kind are being made very widely. Widely, and very wisely, too. We need more of them. However, because they cover only a part of that problem, the colleges, I think, are in the difficult position I spoke of.

With respect to college curricula, I do not think we have to worry. The faculties are constantly revising and improving the curricula of the science and engineering departments, so that is something we do not have to attend to, particularly, where there is accreditation and where schools have to come up to certain minimum standards, in order to graduate students who will be recognized in their fields. But, as I mentioned before, equipment and space and teachers are matters that urgently need attention and they are only just beginning to get recognition.

The American Council on Education has had two conferences on the general problem affecting all the different disciplines, but no one has yet sponsored a program to deal with the needs of the science and engineering departments. We propose to do so before the end of the year, and in fact, that is one of our objectives for 1956 and 1957.

I have dwelt, I think, adequately with the military situation, but may I conclude, Mr. Chairman, with a rather candid statement. I am sorry Mr. Hinshaw is not here to hear it, because I am sure he would have been interested.

Representative PRICE. I am sure Mr. Hinshaw would have been interested in the statements you have given already.

Dr. MEYERHOFF. He and I have worked together, as he said yesterday, but I want to counter one thing he said. It is not exactly countering it, either. He asked Dr. Trytten, you remember, whether the scientists and engineers of the country had ever stood up on their hind legs and howled about the different things that were happening to them, specifically with regard to the treatment of scientists in the military. May I say that there has been, not necessarily some howling, but there have been representations. The scientists and engineers of this country are in rather a sad minority and when they started to howl they were immediately accused of wanting special and favored treatment.

One of the first situations I had to face in the Manpower Commission was the accusation that we wanted to create a class that was treated specially. We have never advocated exemption from military service, in fact we have been firmly opposed to it. We do not want scientists to be spoiled by being made a special class, as is the case in the U. S. S. R.

On the other hand, we have taken the attitude that our science and technology, being no better than our scientists and engineers, does need the attention of the Government, and that professional personnel in these fields may need some special consideration, particularly while we are in such short supply.

We have encountered opposition on a number of points, and I think Mr. Van Zandt, who was present at the hearings in connection with the draft law and the Reserve Act of 1955, will well recall that some of his colleagues on that committee were very difficult to sell on the importance of doing something about our scientists and engineers, so that we could be assured of getting their technical service.

Also, that was a reflected attitude, because that is the way so much of the public feels. We are finding many draft boards completely unsympathetic with any deferments for essential personnel in the scientific and engineering fields. With that public attitude, reflected as it has been until this particular Congress in the attitude of many of our Congressmen, we have faced a serious problem.

Representative PRICE. I have sat through, with Mr. Van Zandt, for many years, these arguments on the House Armed Services Committee. I think he agreed with me, and we agreed with Mr. Hinshaw that no one is asking for a special consideration of engineering and scientific manpower for individuals. What we are thinking about is for the national interest, and the importance of this field to the Government, not only now, but in the future. We were thinking of national interest, and not of individuals, in representations that we have made on this subject before the Armed Services Committee.

Dr. MEYERHOFF. Mr. Price, when I say, as a veteran of World War I that there was no experience in my life that was of more value to me than the experience in the Army as a private and I never even got to first class, because there was not any such in World War I—but I was just a plain private, and it was a most valuable bit of my education. I feel that every young man in this country can benefit individually by service in the Armed Forces, but we are not concerned with the good of these young men solely as individuals. We are concerned with the welfare of the country, and that is why I am devoting these years of my life to this business of manpower.

Representative VAN ZANDT. Doctor, is it not true that we have always given your profession adequate time before the House Armed Services Committee?

Dr. MEYERHOFF. You certainly have, and in fact, I have had a most sympathetic hearing, and my colleagues have, at all times and in the committees of both Houses.

Representative VAN ZANDT. I well recall when we were writing the Armed Forces Reserve Act of 1954, when General Hershey presented to us his plan of creating these State boards to consider these cases, we felt that we probably had the answer to the problem.

Dr. MEYERHOFF. They have helped.

Representative VAN ZANDT. Apparently it is not the answer to the problem.

Dr. MEYERHOFF. No; I think it is not, but at least it helps to the degree that now the local boards get good advice, but there is still this public attitude, you see, Mr. Van Zandt, which comes to us in many

individual cases that we are asked to handle. I have just dealt with a Kentucky board that said, "We will not defer anybody. Period."

Representative VAN ZANDT. I think you will agree that it is practically impossible for us to legislate to meet the personalities of those who compose the various boards.

Dr. MEYERHOFF. Of course it is.

Representative VAN ZANDT. From a national policy standpoint, we want to be fair not only with members of all professions, but to members of draft boards, as well as the commanding officer of a unit or of a military installation.

Dr. MEYERHOFF. That, I think, is the important point. It is not a question so much of being fair to individuals—there is bound to be a little injustice here and there and we can take it—but of getting all that we can from the brains of these people. We want to pick their brains to the limit because we need them. It is the loss there that we are really concerned about.

Representative PRICE. Senator Gore, do you have any questions?

Senator GORE. I have no questions.

Representative PRICE. Thank you very much. We deeply appreciate your kindness in coming here and giving us this fine testimony.

We have talked about this, but we recognize the fact that there is a very serious shortage now and one impending for at least a few years. Do you have any suggested remedy for the situation other than what you have mentioned in your discussion?

Dr. MEYERHOFF. Well, sir, remedies are—if you are talking of legislative remedies—out of my department. I must confess to that. I have tried to think of several different possibilities. One of them is, perhaps, the extension of the Smith-Hughes Act to include not only people in agriculture and home economics but also to give encouragement to scientists and engineers, particularly in the teaching field, especially in high school, where we can get better training by having teachers that may be somewhat favored by this act as compared with their fellows in the same school.

But that act, so far as I know—and may I say I know it intimately, because my wife was a teacher of home economics under it—created no hard feeling at all because the Smith-Hughes teacher was getting a little more salary than someone else. On the contrary, it gave the teacher somewhat more prestige. I think that is one possibility.

I believe, too, that since this brief and incomplete survey of Dean Whittemore has disclosed the fact that our State universities and land-grant colleges are very close to the point of maximum capacity in the engineering fields—and I think that that is true of most of the scientific fields, too, or will be very quickly—the possibility of assisting those colleges in buildings, so that there will be no accusation leveled against the Congress of Federal control of education, might be considered. That is a bugaboo, as you know, and I am sure that you people wish to avoid it, but if, on the other hand, financial aid is given for the construction of buildings and purchase of equipment without strings attached, that will, you see, do two things. First, it will encourage young people who are considering careers, or who have trained for careers, in science and engineering to consider teaching. So it will replenish our supply of teachers and increase it and we are going to need an increase very badly as the college population bulges from the postdepression years.

It looks as if our college enrollments will move up 60 to 70 percent by the year 1970. We have to prepare for that teacherwise, as well as equipment- and building-wise. I think that is an area that this committee might properly investigate. Just how to handle the high-school situation, I do not know. Maybe Mr. Carleton will have some thoughts on that. But I do, sir, make that suggestion of investigating the possibilities of extending the Smith-Hughes Act which will affect the teachers' salaries. As you know, one of the principal causes for the shortage of high-school teachers—any kind of high-school teacher at the moment—is the salary situation.

Representative PRICE. Thank you very much.

Representative VAN ZANDT. May I ask a question.

Doctor, you are familiar with the AEC program that now involves a group of 50 postgraduates who are attending Penn State University, and North Carolina State.

In view of the fact that both of these colleges lack facilities to take a larger group, would you recommend that probably the AEC subsidize facilities so that these two great educational institutions could expand the number of students that they are taking from the AEC?

Dr. MEYERHOFF. I would say, "Yes."

Representative VAN ZANDT. That is my feeling.

Dr. MEYERHOFF. It is mine, too. But now you will find different reactions on the part of educators to subsidies of this kind. So long as there is no control exercised over what is taught there, except perhaps control to the extent that a particular field will be emphasized. Actually, all our universities specialize in certain fields—even the great MIT specializes in some fields of engineering and neglects others. I think that if you could get a cooperative administration, yes, that would be an excellent thing to do.

Representative VAN ZANDT. The 60 students I mentioned previously are only a drop in the bucket, when you look at the overall problem. There should be 300.

Dr. MEYERHOFF. And if we face this acute shortage as has been testified to here several times, we certainly should do something about it.

Representative VAN ZANDT. Now, in regard to the instructors, would you agree with the idea that probably we should go out and borrow these teachers, we will say, who are now employed by industry?

Dr. MEYERHOFF. Yes; you may remember the suggestion made by Mr. Sarnoff recently that industry loan some of its men, qualified to teach, back to the institutions from which they came, or others, and I think it is an excellent idea. May I say, shortly after the Sarnoff speech, James Creese, the president of Drexel Institute of Technology, in Philadelphia, announced at once that Drexel had been trying that and it had been very successful indeed. So it is a potential source of teaching personnel. Industry men on leave can do that. I think that it may help very much in meeting the immediate problem of getting an instructor in a particular subject. Of course, industry needs those people too, and there is the rub.

Representative VAN ZANDT. This is my concluding question, Doctor. I remember you appearing before the House Armed Services Committee over a period of years and you have always impressed me by your testimony.

Now, the question is this: If this committee or Congress comes up with a program to meet this situation, would you suggest that we put it on a crash basis?

Dr. MEYERHOFF. We need a crash program. It would have to be somewhat different and more drastic than the long-range program. We all have to work on the long-range program, and it is a matter that perhaps can be assisted through the Government. Scientists and engineers are rather reticent. They are bad public-relations people and they have not sold their field. Why is it that the public is not more concerned about scientists and technologists? Because they think of the magic of science and the magic of engineering, but they do not see that it is the people that have made that magic. May I say that the scientists and the engineers can take the blame for the complete neglect of public relations.

Now, I think that, with better public appreciation of the importance of science and technology and of scientists and technologists, the situation will steadily improve. But that is the long-range problem, and public education is a slow job, as you know better than I.

On the other hand, we do need a crash program because of the immediacy of the situation.

Representative VAN ZANDT. It should be a program designed to meet the immediate situation as well as our long-range needs.

Dr. MEYERHOFF. Yes, sir.

Representative VAN ZANDT. This would make certain that we never get into this situation again.

Dr. MEYERHOFF. That is right.

Representative PRICE. Thank you very much, Dr. Meyerhoff. We appreciate your testifying.

Dr. MEYERHOFF. May I pledge my service to this committee in any way that I can render it, Mr. Chairman, and if there is anything further that our commission can do it will be glad to. And may I say, for two of my colleagues who have been invited to appear, M. T. Carpenter, of Standard Oil Company of Indiana, and John S. Nicholas, professor of zoology at Yale University, they felt my testimony would probably suffice, but that they are both willing to appear if you still want supplementary testimony from our commission.

Representative PRICE. Thank you very much.

The next witness will be Dr. Robert Carleton, of the National Science Teachers Association. We are glad to have you here, Dr. Carleton.

STATEMENT OF DR. ROBERT H. CARLETON, EXECUTIVE SECRETARY OF THE NATIONAL SCIENCE TEACHERS ASSOCIATION

Dr. CARLETON. Mr. Chairman, first let me thank you for the opportunity to be here.

I am Robert H. Carleton, executive secretary of the National Science Teachers Association. I have held this position since its creation in September 1943. The National Science Teachers Association, NSTA is a voluntary organization of nearly 9,000 members and subscribers. NSTA is a department of the National Education Association and an affiliate of the American Association for the Advancement of Science. We have 69 local, State, regional, and national organizations of science teachers affiliated with NSTA. The general

purpose of our association is to help advance and strengthen the teaching of science at all educational levels—elementary schools, high school, and college—and in all branches of science.

What I shall have to say today conforms fully, I believe, with all statements of views and policies adopted by the NSTA board of directors. Also, I believe that practically all individual science teachers would subscribe to the statements I shall make.

You may be interested to know my own background, beyond my position with NSTA, that might qualify me to have a part in these hearings. Prior to accepting my present position, I was teacher of high-school science for 18 years, beginning in the fall of 1926 in Roosevelt High School in Dayton, Ohio, and concluding in June, 1956 in Summit, N. J. I have had 6 years' experience as a college teacher at New York University, Newark, N. J., College of Engineering, and Michigan State University. My undergraduate work was done at Ohio State University where I majored in chemistry and had minors in physics and biology. My advanced work was done at New York University and Michigan State University.

One thing I wish to emphasize immediately is that I am not a manpower expert. We are told, however, that there is a critical shortage of scientific manpower for industrial and military needs, and I am quite willing to accept this as fact. That we need, or would profit by, more and better education in the basic sciences for more of our youth is a hypothesis—even a creed—to which I have devoted 30 years of professional endeavor, seeking to instruct youth in science and to encourage those with talent and interest to pursue science-related careers.

In this respect, I think I have not been different from thousands of other devoted science teachers who have been serving youth and our country during the past quarter century or more. And the success with which our young people provided the skills and assumed the responsibilities that helped us through World War II and the Korean action may be cited as argument to support the belief that science teachers, and teachers throughout the whole educational profession, have given our boys and girls a good start in life.

My main purpose today is to offer evidence relative to the contention that the present shortage of scientists and engineers is largely due to a serious breakdown in high school science teaching—to sharp declines in student enrollments in science, to lack of interest in science by today's youth, and to a deterioration in the quality of teaching. I shall also suggest some ways at the high school level of assisting to alleviate the shortages and needs which, if not remedied, could produce serious national consequences if not catastrophe. My discussion will deal with the following major points:

I. Student enrollments in science;
II. Course offerings in science;
III. Teacher supply and demand in science;
IV. Quality of instruction; and
V. What can be done at precollege levels?

I. STUDENT ENROLLMENTS IN SCIENCE

It has been said repeatedly that a major factor in the present shortage of scientific and technical manpower is an alleged decline in stu-

dent enrollments in science in American high schools. It has been said, for example, that "only 4.6 percent of high-school students today study physics as contrasted with 19.0 percent in 1900." These are very misleading statistics for the reason that the base of computation is the total number of students in the last 4 years of high school, whereas with few exceptions, physics is offered as a 12th grade course in American high schools. Also, it should be remembered that in 1900 only a small fraction—roughly 20 percent—of the age group 14–17 were in high school, whereas today substantially 9 out of 10 of all youth through age 17 or so are in school. Half a century ago, most of the high-school youth were from home and community environments that encouraged these young people to prepare for college; the high school curricula of the time were attuned to this goal as a prime objective. Today, the American people have decided that as nearly as possible, all youth should continue in school through age 16 to 18—and that our schools should provide curricula adjusted to their needs, abilities, and next-step aims. Naturally, courses have been divided and adjusted and new courses have been added to the high school curricula in the effort to retain more youth in school through the legally required time. Quite naturally, also, the percent of youth in college preparatory courses has decreased as the total school population has increased. But this does not mean, by any stretch of the imagination, that the college-preparatory function of American high schools has been abandoned.

Since the number of pupils in the high school has increased rapidly during the past 50 years, the percentages of pupils in certain college-preparatory science courses may have decreased even though the actual numbers of pupils have greatly increased. This is what has happened in high-school physics. Using the total number of pupils in grades 9–12 as a base for computation, the following table gives the percent of all pupils in these 4 years of public secondary schools enrolled in certain science courses in 1900 and in 1954:

Year	Biology	Chemistry	Physics
1900		7.7	19.0
1954	19.6	7.3	4.6

Source: U. S. Office of Education; published in the Science Teacher, March 1956.

Representative VAN ZANDT. When you take those figures that you used there, regarding high-school students today who study physics as contrasted with 19 percent in 1900, it is 4.6 percent today as against 19 percent in 1900. Can you give the reasons why there is such a decline in the number of students.

Dr. CARLETON. Perhaps at this point we might take a few minutes to give that explanation. First of all, these figures are based on the total number of students enrolled in the last 4 years of public secondary schools. Those are grades 9 through 12. In 1900, as you know, we had a relatively small percent, perhaps only 20 percent of the age group in school. Today that figure is much nearer 90 percent. As school enrollment has expanded, the percent of students engaged in college preparatory work which was the chief function of the high school in 1900, the percentage of students in the college

preparatory courses has tended to decline. As a result physics enrollment appears to have "dived" to use the vernacular.

Now, if we look at the percent of students who actually take this course, among those students who are at the grade level where the course is offered, the figures appear considerably brighter. That is shown in the table at the middle of page 4. According to the Office of Education figures, last year in high-school biology we had 1,293,000 students taking the course, which was equal to 72.6 percent of the enrollment at the 10th grade where the course is normally given. In high-school chemistry last year we had 482,700 students enrolled which is equal to 31.9 percent of the 11th grade enrollment, where this course is commonly given.

In high school physics, 302,300 were taking the course which was equal to 23.5 percent of the students enrollment in the 12th grade of the American high schools.

In other words, it appears that in 1954–55 in American high schools, the equivalent of about 3 out of 4 students at the 10th grade level were taking biology; roughly 1 in 3 students at the 11th grade level was taking chemistry; and about 1 in 4 students at the 12th grade level was taking physics.

These figures do not support the contention that science enrollments in American high schools have nosedived.

It might also be pointed out that biology, which is now taken by about three-fourths of all students, was not even in the curriculum in 1900; nor was junior high-school general science, a course now taken by practically all students for 1 year or more at grade levels 7, 8, and/or 9.

Another way to assess the extent to which instruction in high-school science is reaching youth is to compute the ratio of pupils enrolled in a course to the total number of youth of high school age (14–17) in the population. This calculation eliminates such factors as how many of these youth were or were not enrolled in school and what fraction of those enrolled were taking college preparatory work.

According to the United States Bureau of the Census, there were 6,131,000 youth of ages 14–17 in 1900 and 9,011,000 youth of ages 14–17 in 1954. According to the United States Office of Education, enrollment in high school physics in 1900 was 98,846; it was 302,800 in 1954. Computing the ratios of course enrollees to total age group, we get an index of 0.016 for the year 1900 and an index of 0.033 for 1954. In other words, instruction in high school physics is reaching proportionately twice as many youth of ages 14–17 today as in 1900.

In high school chemistry, the actual enrollment was about 39,500 in the year 1900 and about 482,700 in 1954. The ratios of course enrollees to total age group for this science course provide index values of 0.0058 for the year 1900 and 0.0787 for 1954. Thus we see that instruction in high school chemistry is reaching proportionately about 13 times as many of our youth of ages 14–17 today as in 1900.

II. COURSE OFFERINGS IN SCIENCE

The science curriculum in American high schools is fairly common throughout the Nation. At the junior high school level—that is, grades 7, 8, and 9—general science is the usual offering. It is safe to say that there is no junior high school that does not offer this

kind of course at one or more of these grade levels. Course content and methods of instruction do vary somewhat from place to place, or even from teacher to teacher within a given school.

At the senior high school level—regarded as grades 10, 11, and 12—the sequence of biology, chemistry, and physics continues to be the standard pattern. Here again, course content and emphasis may vary, although the variation is not likely to be as great as in general science. There is no national authority, and little if any State authority, to prescribe rigid course outlines and requirements. Probably more often than not, the adopted textbook is the real basis of course outline and content.

Practically all senior high schools offer biology, although a few are too small to support this course offering every year and may alternate this course with 9th grade general science.

It has been said repeatedly that "50 percent of American high schools offer no courses in chemistry and 53 percent none in physics." On the contrary, by far the majority of high schools do offer these courses, at least in alternate years. The mistaken notion that half of our high schools do not offer chemistry and physics probably comes from a United States Office of Education report (Bulletin, No. 9, 1950) that of 623 schools responding in a sample survey of 1947–48 science enrollments and offerings, 47.8 percent offered physics that year and 49.4 percent offered chemistry that year. In the same report, however, it was pointed out that—

> more schools offer the regular science courses and more pupils enroll in them than was reported by the schools for this study. This is due to the fact that some schools make a practice of alternating science courses in successive years.

A more recent sample study made in 1954–55 by the United States Office of Education suggests that probably not more than about 23 percent of the high schools do not offer chemistry and physics at all. Even this seems like too high a percent. The import of this statistic becomes less pronounced, however, when it is remembered that we still have some 10,000 high schools with enrollments of fewer than 100 pupils. Certainly the schools not offering chemistry or physics would be found among these smaller schools. And in consequence of this, only a very small percent—perhaps as small as 4 or 5 percent—of American high school students are denied the opportunity of electing these courses if they wish to do so.

Other course offerings in high school science account for only a small percent of total enrollments in science. There are related science offerings in the vocational education program. Some schools have added courses in general physical science, radio, photography, meteorology, aeronautics, and the like; but in the bulk, these courses enroll relatively small numbers of pupils and they attract almost no college-preparatory students from the common sequence of biology, chemistry, and physics.

III. TEACHER SUPPLY AND DEMAND IN SCIENCE

Hardly anyone will deny that the teacher is the key to effective instruction—in science as in all other courses in the total school program. The science teacher is in the best position to recognize the innate capability of the student, arouse and sustain his interest, spark his imagination, and encourage him to set his stakes high and not be

sidetracked by immediate opportunities for highly remunerative employment. Small wonder, then, that so many people have been concerned at diminishing production of new science teachers by our teacher-training institutions—and that so many palliatives and stopgap measures have been proposed to alleviate the shortage. How severe is the shortage?

According to figures from the National Education Association's Annual National Teacher Supply and Demand Reports, the gross production of bachelor's degree, newly certified science teachers for the last few years has been as follows:

Year	Graduates with major preparation in science	Percent change from 1950	Year	Graduates with major preparation in science	Percent change from 1950
1950	9,096		1954	3,641	−60.0
1951	7,507	−17.5	1955	3,754	−58.7
1952	5,246	−40.3	1956	4,434	−51.3
1953	4,381	−51.8			

These figures do indeed appear quite bleak. It should be remembered, however, that 1950 was a peak year and an abnormal one due to the graduation of the World War II veterans under the GI bill. As of next June 1956 we can expect about 4,400 new science teachers to come out of the colleges and universities. This is still more than 50 percent under the peak of 1950; but a more optimistic view is that the 1956 crop will be better than 20 percent above the low of 1954.

Even so, school officials need greatly increased resources with which to attract into teaching a higher percentage of these young people who made the decision and successfully completed the preparation to become teachers. In recent years, only a little more than 50 percent of the June science-teacher graduates have actually entered teaching the following September. Higher paying jobs in science-based industries have been a terrific competitive factor. The going rate of pay for bachelor's degree scientists in industry is in excess of $400 a month. I recently sat with a committee that included a young science teacher from one of the Knoxville, Tenn., high schools. He has his master's degree and has been teaching for 6 years. His salary this year is $3,000. Ironically, the committee was pulled together to advise with officials of the Oak Ridge Institute of Nuclear Studies on the design of a program directed toward the improvement of science teaching and the stimulation of more young students to become scientists and engineers.

Other major causes of the drainoff of new science teachers from the teaching profession are the necessity of completing military service and continuation in college or university for graduate work. It should be remembered, however, that except for those who die, all of the science-teacher graduates of a given June who do not enter teaching the next September continue in the population as qualified, certified science teachers and potential entrants into the profession at some later date.

Now let us turn to demand. One year, 1955, will suffice for an example. As of last September, school officials over the Nation employed 8,646 new teachers to teach part- or full-time in science. (A

new teacher is one who was not employed as a teacher the preceding year; he may be an inexperienced college graduate of the current or earlier year; he may be a former teacher, a returning serviceman, a worker in any other painful occupation, an unemployed person; he may or may not be adequately prepared for the assignment he accepts—the only criterion is that he satisfied a demand for a person to join the total high-school teaching corps of the Nation.)

Of the 8,646 new science teachers employed last September, 4,152 were assigned to full-time teaching of science; 1,752 were employed to devote more than half time to the teaching of science, and 2,587 were assigned less than half time to science teaching.

The class of 1955 produced 3,754 fully prepared prospective science teachers; and 2,114 (56.4 percent) of these entered teaching last September. This means that school officials employed additionally 6,350 new science teachers from other sources. Now the easy conclusion is that many if not most of these 6,350 teachers were substandard. This is probably not the case, for reasons suggested in the above definition of new teachers. But the fact is, nobody knows. We simply do not have data on these new teachers; we do not know how many came from programs of graduate study, or from completion of their military duty, or from industry, or from other sources; we do not know how many were employed on temporary or emergency certificates. This, incidentally, is only one of many gaps in our knowledge of the total situation.

Another clue to the situation we face is the science teacher supply-demand ratio. This is the ratio of degree-holding, newly certified college graduates produced in June of a given year to the number of new teachers employed by school officials the following September. The following table gives such ratios for the years 1950 to date for each of four major fields of science teaching in junior and senior high schools:

Year	General science	Biology	Chemistry	Physics	High school, total	Elementary school, total
1950	1.01	2.89	2.78	2.00	1.63	0.55
1951	1.26	3.14	3.17	2.76	2.02	.75
1952	.92	2.25	2.39	1.41	1.64	.77
1953	.79	2.72	2.00	1.20	1.32	.56
1954	.58	2.12	1.51	.91	1.33	.50
1955	.64	1.68	1.02	.58	1.13	.53
1956	.48	1.48	.90	.50	1.02	.43

Source: National Education Association.

These figures suggest that even though improvement is being shown in gross production of science teachers, the supply of new science teachers is still lagging proportionately behind the demand arising from the need for replacements and to meet increasing enrollments.

Again, however, it should be emphasized that the facts are unclear as to how many teachers of science are being assigned to positions for which they are not fully qualified, or how many science classes may have been closed out for lack of science teachers, whether qualified or not qualified.

IV. QUALITY OF INSTRUCTION

The extent of student enrollments in science, the supply of science teachers, and possibly other factors seem beside the point when one inquires, "What is the quality of instruction?" And with this question, of course, we enter the realm of opinion, prejudice, and relatively few objective criteria for judgment. As a teacher and science department head during 18 years of high-school science teaching, I would be the first to agree that there appears to be a marked difference among teachers in the effectiveness of their science teaching and contacts with youth. To objectify and to specify the evidence, however, is difficult if not impossible. The teacher of science performs an extremely complex task; it is far more than the mere teaching of scientific facts and the testing of students' memorization of these facts. A given teacher may be effective in some aspects of science teaching and not in others; he may be effective with some students and not with others. Nevertheless, it is commonly asserted that more capable students would follow careers in science and engineering if their high-school science teaching was more inspired and up to date, if there was more realistic laboratory work and less of just "chalk, talk, and textbook." There is enough truth in the assertion to cause us to take more than a second look at its implications.

While it is true that the science teacher is probably in the best position to be a prime motivating influence with his young charges, he is by no means the only motivating factor influencing young people in their choices and decisions. Parental influence, financial resources, health, what is seen and heard by radio and TV, what is read in newspapers, and what is not seen and read in the way of properly prepared career information and guidance materials all enter the picture. It appears that college graduating classes could be twice as large as they now are, and without loss of intellectual quality. With more effective guidance and motivating materials, plus increased financial support, it appears that the college freshman class of September 1955 could have been increased by some 150,000 or more students of high ability and promise (based on the report of a study conducted for the National Science Foundation by the Educational Testing Service). Presumably, science would have gotten its "share" of these high-ability students. Recall that 56 percent of over 5,000 semifinalists in the National Merit Scholarship competition expressed an intention to enter upon careers in science. A report of the 1956 scholarship examination conducted by the National Honor Society of the National Association of Secondary School Principals is now being made ready for publication. This report will show that 12,154 students in the upper 5 percent of this year's graduating classes of 2,819 high schools took the examination; 5,280 were boys and 6,874 were girls. Of these bright young students, 2,911 or 55 percent of the boys and 423 or 6 percent of the girls expressed their present intention to major in science or engineering in college. Dael Wolfle has pointed out, however, that only 6 out of 10 of the top 5 percent of all high school graduates earn college degrees.

Some college and university authorities have been quoted as saying that entering freshmen are ill-prepared for college work in science and engineering. Others, contrariwise, have stated their opinion that today's entering freshmen are far more knowledgeable and adaptable

than their counterparts of earlier years. And so again we enter an area of opinion and controversy. The only point I would like to argue is that the relatively high mortality rate (up to 40 to 50 percent in some instances) among college students in science and engineering does not necessarily prove that the high schools are deficient. It could suggest with equal validity at least two other possibilities: (1) That the selection and admission procedures of the colleges and universities are subject to considerable improvement; (2) that the performance of college and university professors as teachers and as guidance counselors could stand upgrading. My own experience on college faculties leads me to believe that all too often the attitude is that "standards" will be maintained by arbitrarily flunking a certain percentage of the freshmen (20 percent in 1 institution in which I taught) as a lesson or an influence for the rest.

V. WHAT CAN BE DONE AT PRE-COLLEGE LEVELS?

I share the hope and feeling of necessity that we can increase the percentage of our population engaged in scientific, engineering, and technical endeavors. I also share the view expressed a good many years ago by John Dewey; namely, that—

> the future of our civilization depends upon the widening spread and the deepening hold of the scientific habit of mind.

Adding these two goals together, what we must seek, it seems to me, is more and better designed science instruction for all boys and girls in the elementary schools and in the junior and senior high schools. This imples differentiated curricula, better methods and instruments for identification and guidance of science-talented students, more adequate facilities and equipment for teaching science, and the widespread acceptance of a reasonable workweek for the science teacher based on a better realization of what the good job of science teaching entails. At the same time, I personally believe—and I think the NSTA board of directors and our membership at large will support the proposition—that the best promise of solid improvement in science teaching is through solid improvement in support for education across the board—in better salaries for teachers, in school buildings and facilities, in budgets for supplies and equipment, and through enhanced prestige for the entire profession. I would not support any move, and in fact I think it would be hazardous, to separate the teaching of science and mathematics from other aspects of the educative endeavor and treat these fields as skill or technical subjects or as aspects of vocational education.

In the final analysis, the problems of making high school science teaching more effective will be solved—or will not be solved—by the science teachers themselves. What happens day by day, teacher by teacher in the crucible of the classroom and laboratory will determine the extent to which improvements are made. As the major organization of science teachers in the United States, the National Science Teachers Association has long been aware of the problems, needs, and opportunities; we have kept in close touch with science teachers, educators, scientists, and industrial leaders in seeking advice on what an association like ours can do and should be doing.

In 1952 we established the future scientists of America foundation as our special agency to deal with scientific manpower problems as

they come into or affect high school science teaching. As evidence of what our association and our future scientists of America foundation are doing, I submit a list of these 11 exhibits.

(The list referred to follows:)

Careers in Science Teaching, a student guidance booklet.
Encouraging Future Scientists: Materials and Services Available in 1955–56, a listing of sponsored incentive programs, and guidance materials and services.
Encouraging Future Scientists: Student Projects, a booklet giving ideas for student projects.
If You Want To Do a Science Project, a booklet telling how to start, complete, and report worthwhile projects.
The March 1956 issue of The Science Teacher, our asociation journal.
Announcement—application for the 1956 west coast summer conference for high school science teachers.
Announcement—application for the 1956 summer conference for Wisconsin high school chemistry teachers.
Announcement—application for the science teacher achievement recognition awards program.
Announcement—application for the fifth annular program of science achievement awards for students.
A list of the students winning awards in the above program this year.
A brochure, Facts About the Future Scientists of America Foundation.

Dr. CARLETON. What can other groups and agencies do? This is a very large question with numerous and diverse answers. But here are a few suggestions and comments.

1. The United States Office of Education might well expand its present staff of specialists for science and provide them with better budgets for research, the preparation of bulletins, and consultative services in the field. Five years ago before the situation was recognized as critical, the Office of Education had six specialists for science on its staff. Today it has 3—1 in engineering education, 1 in high-school science (appointed only last December to a post that has been vacant for 2 years), and 1 part-time in elementary science.

2. State departments of education and city and county school systems might well provide more personnel and improved services of a supervisory or consultative nature in science.

3. There is great need for curriculum and instructional materials to be produced as supplementary to the commercially available textbooks and laboratory manuals. These materials should be produced by and within the science teaching profession as instructional aids and guides for inexperienced teachers, teachers with assignments outside their major field, and to encourage effective teaching in such relatively new areas as radio and electronics, nuclear science, health science, and others.

4. There is great need for research and experimental studies in the teaching of science. The pattern of physics teaching today, for example, is essentially the same as it was 50 years ago. We need a bold, imaginative approach to the teaching of science and mathematics. The science-based industries invest very large amounts of money in research and development; education struggles along mostly on the meager research that teachers can do as they grind out graduate programs. One hundred thousand dollars a year for 5 years would enable a program of research and experimentation in science teaching that otherwise would take perhaps 50 years, or never, to do.

5. Support is needed to encourage and enable classroom teachers of science to conduct and report experimental work and the testing

of new ideas in the very best laboratory of all—the science classrooms of the Nation.

6. Financial support for specially designed summer opportunities for science teachers should be continued and expanded. There are 2 criticisms of this effort, however; first, it is a snail's pace method of reaching the more than 60,000 teachers of science in junior and senior high school, and secondly, more often than not, these programs seek the better qualified teachers as participants and thus tend to overlook the teachers who are not so well qualified and therefore stand to gain the most from such opportunities. Nevertheless, these summer programs provide new information, new ideas, and new inspiration for the teachers they do reach and the effort should be expanded.

In closing, may I thank the subcommittee for the opportunity to file this statement as part of its hearings. The National Science Teachers Association feels that it is rendering service and exerting an influence all out of proportion to the meager budget on which we operate, only $35,000 of which comes from membership dues and subscriptions. If we can be of further assistance, we are anxious for the opportunity.

As I said before, the National Science Teachers Association is a department of the National Education Association. The president of the NEA, Dr. John Lester Buford, of Mount Vernon, Ill., has asked me to express to the subcommittee his deep regret that a series of prior commitments will prevent his appearing before the subcommittee in person. He is working on a statement which he would like permission to file with the subcommittee, before the close of the hearings. If this is agreeable with the subcommitte, I will let Dr. Buford know as soon as I return to my office.

Representative PRICE. I think that your figures are accurate, and I do not think that there is any disagreement with your figures in the study with the committee caused to be done by the Legislative Reference Service of the Library of Congress.

I think, however, that what we must consider here is whether or not there is a shortage as against the demand for engineers.

In 1900 I would imagine that you had about 1 engineer per 1,000 other workers, and today you probably need 1 engineer for about 65, or maybe 100 workers. So there is a relative matter there, and the need is based on the demand rather than how many were in these fields in 1900, as against today.

Dr. CARLETON. I would agree 100 percent with what you say. What I have reported or summarized here is not in relation to your question, but is primarily to explain away, I might say, the repeated claim that the present shortage is due to this apparent nosedive, or serious decline in high-school enrollment.

Actually, I think that that has not been the case. On the other hand, it is a very large and important question as to what high-school people can do and should be trying to do to increase proportionately the number of the percentage of our population engaged in the scientific endeavors.

Let me say that our association is in business for the prime purpose of extending and strengthening science teaching in the schools, elementary, high school, and college.

As far back as 1951 we began to take steps to cope with the emergencies, and in 1952 we established as a special agency of our association the Future Scientists of America Foundation.

I have submitted, as supporting evidence of what we are doing, a package of 11 documents that reveals our programs for teachers and students. This effort is supported primarily from contributions from industrial sources, and the budget at the present time is running roughly $60,000, or only about $1 per high-school science teacher.

Representative PRICE. Do you tell us in your prepared statement about the nature of your organization and its makeup, and so on?

Dr. CARLETON. Yes; I have given that, Mr. Price.

Representative PRICE. I notice in your first suggestion, you state that the United States Office of Education might well extend its splendid staff especially for science and providing them with better budget for research and the preparation of bulletins and consultative services in the field.

In what way are the schools handicapped by the reductions in this effort on the part of the Office of Education?

Dr. CARLETON. That might be hard to specify, but I might say in terms of my contact with the field, there is need and there are requests for many times the presently available consultative services from recognized leaders, who might serve in an advisory capacity with curriculum development committees or leaders in workshops of short duration, or for services of that kind.

There is terrific need for more and better research. For example, right now, we simply do not know the qualifications or origins of science teachers, or the status of science teaching in the schools. We have no knowledge about the support for high school science teaching in terms of budgets for supplies and equipment.

I could go on, but perhaps that would illustrate the kind of thing I think the Office might do.

I would like to emphasize that 5 or 6 years ago, before this situation had been identified as being as critical as it is, the Office of Education was supplied with six specialists in the field of science, at elementary and hgh school levels.

As I pointed out in my statement, today there are 3 such people in the Office, 1 of whom is available in science only perhaps 25 percent of the time.

The second one was appointed only last December to a position that had been vacant for over 2 years.

Representative PRICE. Your organization feels this type of service at the Government level is not only useful, but very important in the training program?

Dr. CARLETON. Yes, sir.

Similarly, we recommend, and we have been trying to help stimulate improved services of a rather similar nature at the level of State departments of education.

While many States, and probably all, provide some attention to science teaching through general supervisors, I believe only four States have any staff personnel in the State department clearly identified as a supervisor or consultant in science and mathematics. Those States are New York, North Carolina, Indiana, and Hawaii has 1, and Puerto Rico has 1. Connecticut recently has appointed a definite consultant in science.

Representative PRICE. What is your thinking in your suggestion No. 4, the bold, imaginative approach to the teaching of science and mathematics?

Dr. CARLETON. In terms of the exercises outlined in a typical high school laboratory manual of physics, we are still performing, I would say, in terms of the 1890 to 1900 pattern. Teachers need and want new workable ideas for up-to-date laboratory work.

We still block out our instruction in science piece by piece.

Biology is compartmentalized apart from physics, and so on.

To answer specifically, through one example of what I would call a bold, imaginative approach, I would like to see set up in perhaps 6 centers, 3- to 5-year experimental runs of attempting to merge the teaching of science and mathematics at least for identified bright youngsters with interest and talent in science so that we might work with these youngsters across the board in science and mathematics, through a continuing period of 2 or 3 years, rather than this present piecemeal approach.

We might, for example, experiment with setting up special summer-school programs for bright youngsters, and I feel fairly confident that if through a pilot run of this idea that it could be demonstrated to be effective, and educationally acceptable, many school boards and school districts could be encouraged through their own programs to provide similar opportunities.

One of the most critical levels and, in my opinion, where we lose a great deal of interest in science is at the junior high school level, where practically 100 percent of the students are enrolled at least 1 year in grades 7, 8, and 9.

Unfortunately, if there is a shortage of qualified teachers, high school principals tend to nurture their better qualified teachers for the upper levels, and perhaps they should.

This means that per force teachers in many cases not prepared in science are given 1 or 2 classes in general science and unfortunately the teacher lacks experience or imagination or subject matter qualifications and the instruction degenerates to what I call blackboard, chalk, and talk.

Youngsters being active and wanting to engage in the doing side of science, tend to lose interest. I think this loss of interest is reflected, then, in the reduced enrollments in the elective courses, particularly chemistry and physics.

Representative PRICE. Is that a general situation all through the school system, throughout the country, or can you think of any school system that has approached it along the lines that you are talking about in this bold, imaginative approach you referred to?

Dr. CARLETON. There are some experimental efforts. To the best of my knowledge, they are not numerous, nor have they been well publicized or reported.

Perhaps the outstanding example would be the Bronx High School of Science where here we have an entire high school devoted to a program for bright youngsters in science and mathematics.

Representative PRICE. Where is this located?

Dr. CARLETON. It is in New York City.

Representative PRICE. That is the Bronx High School of Science?

Dr. CARLETON. Yes, sir.

Representative VAN ZANDT. How many students are enrolled?

Dr. CARLETON. I am not sure. I feel confident it is in the neighborhood of 2,000, plus or minus a few hundred. The Stuyvesant High School in New York City is essentially a science high chool, while it is not called that. They enroll some 6,000 boys only and they have electrical shop equipment and other forms of scientific apparatus that would be far superior to that found in many colleges.

Personally, I am of the opinion that high schools over the country, enrolling as few as 500 students or so, could operate this high school of science idea within the high school itself. Begin with better supported, firm convictions on the part of administrators and teachers that science teaching is important, and, secondly, better instruments for identification of youngsters with capabilities and interests in science and mathematics, and, thirdly, provide the teachers with resources to handle these youngsters in better designed programs.

It may be administratively difficult to pull out of a student body of 600, let us say, 50 or 60 bright youngsters and give them special treatment as an identified group of students.

But I think that it can be done, and in fact, I know it is done in a number of high schools.

Representative VAN ZANDT. In my part of Pennsylvania, all of our schools have a vocational department. Would you say that we should add to the vocational department a department of science?

Dr. CARLETON. No, sir; I think that would be moving in the wrong direction. I think the minute we make a move to separate science and mathematics from the total educative endeavor for all boys and girls, we are doing harm and we are defeating the purpose we are working for.

I would not like to see science and mathematics teaching moved in the direction of treatment simply as skilled or technical or vocational subjects.

Representative VAN ZANDT. What would you suggest, then? How could we encourage young men to enter the field of science? I am now speaking at high school level.

Dr. CARLETON. I am sorry; I think that I lost the first part of your question.

Representative VAN ZANDT. What would you suggest we do to attract young men to the field of science?

Dr. CARLETON. The most basic factor is a good teacher.

For the past several years, according to the reports from the National Education Association Study of Teachers' Supply and Demand, we have been losing about 50 percent of the annual crop of new teachers coming out of colleges and universities through three primary reasons.

A very important one is loss to higher paying jobs in industry. There are, of course, those who face necessary military duty. Some continue through choice with programs of graduate study.

Now, it is true that except for those who die, all of these newly graduated certified teachers remain in our population as potential later entrants into the profession. Last year, the colleges turned out roughly 3,700 new teachers of science, prepared and certified. Only about 2,100, or 56 percent, actually entered teaching last September.

At the same time, last September, school officials hired nearly 8,500

new teachers for science, full- or part-time. These teachers were new in the sense that none of them was teaching the previous year.

Clearly, then, school officials last year found something over six thousand new science teachers from other sources than the previous June's college graduating crop.

I think it would be too hasty a conclusion to assume these 6,500 were substandard, but this, again, is one of our gaps, the gaps in our knowledge. We simply don't know how well qualified these people were, and whether they came from graduate programs, or whether they came back from military duty, or whether school officials with increased resources were able to attract some back from industry.

Basically, to come back to your question, give a good teacher, enthusiastic and dedicated—and I would accept that most of those who make the decision and go through with the preparation to be teachers could be classed in this category—give them adequate facilities to work with, laboratory equipment and supplies and textbooks and a reasonable workweek, by which I mean time to plan for laboratory work and time to plan for field trips, and to do the many other things that the job of science teaching entails, and provide them with interesting and effective career information and guidance materials which are coming in fairly good supply from industries and other sources, and technical and scientific societies, and I think we could place our trust in a good job and a bright prospect for the future.

May I illustrate with one brief example what the situation is with respect to salaries for science teachers.

In early January I was called to meet with a committee in Oak Ridge, to advise with Oak Ridge Institute of Nuclear Study officials on the design of a program which they will offer to schools next September with support from the National Science Foundation.

One member of this committee was a young, vigorous, dynamic science teacher from one of the Knoxville high schools. He had his master's degree and has 6 years of teaching and his salary, I think, this year, is $3,000. The going rate, as you know, for bachelor's degree young entrants into science and engineering is certainly $400 or more per month.

Representative PRICE. Do you have average figures over the country on science teachers?

Dr. CARLETON. Not apart from the total teaching staff. I don't believe the salaries of science teachers have been pulled out for separate treatment.

The average last year was somewhere around $4,100, I believe.

Representative PRICE. For high school classroom teachers?

Dr. CARLETON. Yes. The average years of experience, and this is somewhat of a guess, but fairly safe, I think, was probably between 15 and 20 years. The average age of our teachers is going up pretty rapidly, especially in science and mathematics.

Representative PRICE. Before I fail to do so, at the conclusion of your remarks, you requested that the president of the National Education Association, Dr. Buford, be permitted to file a statement with the committee.

We certainly will be pleased to have you do that.

(Dr. Buford's submitted statement appears on p. 477.)

Dr. CARLETON. Thank you.

Representative PRICE. I wonder if you could elaborate on your suggestion No. 6. I think that you have in some way touched on it, and you mentioned some problems there, and some difficulties involved.

Dr. CARLETON. Yes. This is somewhat of a complex problem, again, but in a study conducted in 1952, when we launched our Future Scientists Foundation, one of the first things we did was to go to our membership to ask for advice on what science teachers themselves saw as the needs and gaps, and what they wanted for themselves, and what they wanted for their students.

The outstanding request for opportunities for themselves coming from the science teachers was for summer opportunities for employment in science-based industry, so that they could gain actual experience and new ideas and at the same time supplement their salaries.

We have been promoting that program as have other groups for the past three years.

The second item they specifically requested was better designed and more realistic summer programs of courses, workshops, and institutes, and the like.

Now, we think that our science teaching force numbers at least 60,000 teachers in junior and senior high schools. We will be years on end reaching them all, and upgrading them all through summer programs. That is taking 50 at a time, and 30 here, and 40 there, in 1 conference and another.

On the other hand, there is no question but what teachers are extremely enthusiastic at such opportunities. They go home with new enthusiasm having exchange promising ideas and experiences.

As you know, this coming summer, through the support of industrial organizations, the National Science Foundation, and in cooperation with many colleges and various other agencies, there will be some 30 or more summer programs offered to science teachers providing opportunities with financial assistance in the form of stipends and fellowships for perhaps twelve to fifteen hundred teachers.

Representative VAN ZANDT. You say for twelve or fifteen hundred teachers?

Dr. CARLETON. Probably, this summer; yes.

These, in many cases, are experimental in design. Within our association I think that we have offered three main criticisms and in our own designs we have attempted to do something about these criticisms.

First, generally these programs are designed at the selection stage to bring in the teachers who are already better than average in their qualifications. This means that teachers who are less well qualified and perhaps stand to gain most from these programs and may be in greatest need are often passed by.

Second, this is a very slow rate of reaching the total corps of science teachers. There are a few programs this summer that are designed to reach the leaders of the profession, you might say, the department heads and supervisors.

The third point that we have felt somewhat critical about is that the results of these conferences, except for a halo effect, have been confined to those who actually participated.

So, in our program, which is a very modest one, consisting of two summer conferences, we have consistently asked the conferees to produce a report to the profession, which report then we have published

in our journal going to 10,000 members and 20,000 readers and subscribers.

The idea is that to the extent we can communicate through the printed page, this selected group of teachers on stipends have, in a sense, a responsibility to serve the other members of the profession as fully as they can.

I say there is room for great expansion in efforts of this kind; let me be specific with one example.

This coming summer, the last 2 weeks in August, we will run a 2-week special conference for teachers of chemistry in Wisconsin. The company who is supporting this, the Marathon Corp., specifically requested that the participants be selected from the smallest radius necessary to get 30 participants, with the center of that area being the plant community of the corporation.

So we rounded up the names of all chemistry teachers near enough to the town where this corporation is located to give us a list of about 40. We extended them an invitation to accept $250 and come to this conference for 2 weeks. At the moment we have about 20 acceptances.

This means that first we will have a much better cross section of chemistry teachers as they are in this one small area of Wisconsin.

Second, it means, or so it seems to me, that almost 100 percent of the high-school teachers would be ready, willing, and able to accept opportunities of this kind offered within their own rather limited areas.

Representative PRICE. There was one other thing that I wanted to ask you about. In trying to follow your statistics on the number or the percentage of students who take physics today as against 1900, undoubtedly the figures that you have given in the statement are correct.

However, I see the problem in this way: I have a feeling that the figure has nosedived and you have a feeling that the figures indicate that actually it has not nosedived.

But your overall high-school enrollments today on these figures would average about 400 percent increase.

Now, in order to keep the pace even with 1900, we should have a 400 percent increase in physics students. I do not think that these figures bear that out.

Dr. CARLETON. No; they do not. The reason, I think, is this: In 1900 the high-school enrollment was substantially 100 percent college-bound youngsters, and this great expansion in our total school population has come mostly at the other end of the spectrum of ability and college preparatory objectives.

I think it is a question that needs to be looked into and the answer we don't have at the moment is how much of an expansion we can reasonably expect in science enrollments at the high-school level in physics and chemistry and mathematics, if we wish to continue teaching these courses at the level of attainment to which we have been accustomed and aiming.

Our association is engaged right now, this minute, in a study and we have sent an inquiry to all 25,000 high-school principals asking for information on school enrollments grade by grade, and science-course enrollments grade by grade, and course by course from grades 7 through 12.

In addition, we are asking for a report on the percent of students engaged in college preparatory curricula. The assumption here is that we are not likely to get future scientists and engineers from

students enrolled in the business or commercial courses, or in industrial arts, or vocational educational programs, and the like.

Now, if we discover, and this is guessing a bit, for example, that 57 percent of high-school students are in the college preparatory curriculum, and only 35 percent are taking chemistry, then we have a much better notion of how much of an expansion it would be reasonable to expect. That is information that is now not available. That would identify one opportunity to increase the pool.

Second, another great loss and opportunity to increase the pool as we know, is the serious loss in qualified high-school graduates prepared to enter college and having the intellectual capacity for success, but who are not motivated to go to college. Estimates have varied, but I think that we are safe in saying that somewhere in the neighborhood of 40 percent of the upper 25 percent in ability of our high-school graduates do not enter college.

Apparently, the lack of financial resources is a serious item for only about half of these.

The third great opportunity, in my opinion, to increase the pool is at the college level where we have now about twice as many students who apply for admission to college programs and are admitted and are accepted and started on their way as graduates. About 50 percent fall by the wayside and do not complete their college programs.

I have been a college teacher as well as a high-school teacher, and I would not hesitate to say that the college professors have a long way to go in upgrading themselves in their competences as teachers and as guidance counselors.

In one institution in which I taught, it was the opinion of the head of the freshman chemistry department that just arbitrarily, regardless of grades, 20 percent of the freshmen should flunk as a means of maintaining standards. Where that attitude prevails, I think that we are moving in the wrong direction.

So I see three opportunities to increase the pool. First, it is better identification of the students with potential in high school; that is, coupled with better guidance, information, and instruments.

Secondly, it is increasing the number of qualified high-school graduates who actually enter college.

While the high-school teacher may be a prime factor at this stage, he is not the only factor. Parental influence, financial resources, and health and what we see and hear by radio and TV, in the newspapers, and what we don't hear by way of career information and the needs for scientists and engineers—all of these are factors.

The third is through greatly improved efforts at retention and instruction at the college level.

Representative PRICE. Do you have any further questions?

Representative VAN ZANDT. How many high schools do we have in the country in round figures?

Dr. CARLETON. The present mailing list of the National Association of Secondary School Principals includes about 28,000 high schools, secondary schools of all categories, including all of them.

Representative VAN ZANDT. How many of these schools are equipped to teach physics and chemistry?

Dr. CARLETON. We have heard it said that half of our high schools do not offer chemistry and physics. That is not true. I know where that figure came from and it was from a report by the Office of

Education in 1950, reporting a study of course offerings in 1947 and 1948.

Among the schools who reported, roughly 50 percent said they were teaching chemistry or physics that year. It was pointed out in the text of the report, and this has been repeatedly overlooked, that with 10,000 roughly high schools with fewer than 100 students each, many of these schools alternate these courses successive years.

I have been informed that a similar sample study done by the Office of Education last year indicates that probably not more than about 25 percent of the high schools do not offer these courses at all.

Representative VAN ZANDT. Would you say that 75 percent do offer courses, in chemistry and physics?

Dr. CARLETON. I think that would be a safe assumption.

Representative VAN ZANDT. How many high-school teachers do we have in this field?

Dr. CARLETON. The best estimate we have of science teachers, teaching one or more classes in junior and senior high schools, is somewhere around 60,000. About half of them are full-time teachers of science.

Representative VAN ZANDT. You said that the average pay for that group was $4,100 a year?

Dr. CARLETON. That was the average pay for all teachers in all fields last year.

Representative VAN ZANDT. You were unable to actually pinpoint the average salary of chemistry and physics teachers?

Dr. CARLETON. That is right, but in general, there is no separate treatment for these teachers.

Representative VAN ZANDT. As you have said the average length of service is 15 to 20 years?

Dr. CARLETON. That is a kind of a guess. It is somewhat of an impression, but I think it is fairly close. We have not been pulling in very many young teachers during the past half dozen years.

Representative VAN ZANDT. I think the problem that we have in front of us if we are going to increase this reservoir of physicists and scientists, is to really encourage the high schools that are not teaching chemistry and physics today to teach these subjects; is that right?

Dr. CARLETON. I think that would be desirable, but since these schools who do not now teach these courses are the very smallest schools, the percent of students involved is probably not more than 2 or 3 or 4 percent, so that will not greatly increase the pool in my opinion. It is it desirable, of course.

Representative VAN ZANDT. Let us consider teachers. What is our shortage in teachers today in this field? You say we have 60,000 teaching chemistry and physics, and can you give us a figure on the shortage of teachers?

Dr. CARLETON. I cannot, because there is a great lack of knowledge as to the characteristics of the teachers employed in recent years as new teachers beyond those who came out of colleges the previous June.

Just yesterday I was helping to judge a science fair over in Baltimore County and I asked the science supervisor this same question, "Are you short of teachers?" and the answer was "Terrifically."

My next question was, "How many classes have you had to close out in Baltimore County because you have not been able to get a teacher of science for those classes, qualified or not?"

He paused a moment and then he said, "None."

Now, the answer is—school officials will put some teacher probably in charge of the classes who have elected to take these courses. I think it would be an extremely difficult question to try to get the degree of qualification of these teachers to do the job. We could find out how many are employed on temporary or emergency certificates, but we don't know that at the moment.

Representative VAN ZANDT. This is my concluding question. Could you give us your suggestion as to how we could meet this problem immediately?

Dr. CARLETON. That is a tough question. If I had that answer I probably would have some offers for other jobs or forms of service I would not be in teaching.

Frankly, I don't think that there is any overnight or very short-range—months or a year, or even 2 years—answer the problem. It is a long-range problem. I think the best prospect for solid improvement in science teaching is through improved solid support for education across the board.

I don't believe that we will get support for the idea that as of next September we might double the salaries offered science teachers as opposed to others. Even if we did, I don't think it would guarantee automatically a great gain in the quality of instruction or the degree of motivation that teachers could provide.

This is a long-range proposition. I think that you see it in school systems where, over the years, through better local support, these schools have been able to offer higher than average salaries. Over the long haul they have obtained a better than average faculty.

The quality of the program put on by these schools is reflected through this improved support.

Representative PRICE. Thank you very much. We appreciate very much your testimony.

The next witness will be Admiral Rickover.

STATEMENT OF REAR ADM. H. G. RICKOVER, UNITED STATES NAVY, CHIEF, NAVAL REACTORS BRANCH, DIVISION OF REACTOR DEVELOPMENT, UNITED STATES ATOMIC ENERGY COMMISSION

Representative PRICE. I think there is one question I would like to ask you before you get started.

Do you feel that there is in fact a shortage of scientific and engineering talent?

Admiral RICKOVER. Yes, sir, and I am talking from my personal experience over a period of many years, not only in the atomic power field, but also from many years of engineering experience in the Navy.

There is a considerable shortage of scientists and engineers, and the grave problem which faces our country today is how to provide the trained men and women to maintain the momentum of our rapidly expanding technical civilization.

Representative PRICE. Is it to the point in your field where as yet that it has adversely affected the atomic energy program?

Admiral RICKOVER. That is a hard question to answer, sir, because one can approach the problem two ways: From the theoretical standpoint of what we ought to have, and then, again, what one can do himself to take care of his own problems.

Many of these problems can be solved locally by those responsible if they realize that they themselves must take effective action instead of wringing their hands all of the time and expecting others to do it for them.

Representative PRICE. Admiral, would you care to proceed now?

Representative VAN ZANDT. May I ask a question there?

Admiral, in the construction of the *Nautilus*, is it not true that the Westinghouse people had some 3,500 subcontractors?

Admiral RICKOVER. They had a large number and that in itself constituted a considerable education in atomic energy for many subcontractors.

Representative VAN ZANDT. I am wondering, in your own experience now, did you encounter any deficit on the part of these Westinghouse people or their subcontractors as far as necessary engineering brains were concerned?

Admiral RICKOVER. Yes, sir; we not only have encountered it, but we still encounter it.

On the other hand, any man in charge of a project who feels fully responsible for it must realize that an inherent part of his duties is to train people from the very start of the project. Of course, if one is assigned a project and is furnished all of the money he needs and all of the trained people required, he might as well go fishing, because there is then nothing left to do. There is nothing difficult about running a project if one is given everything he needs.

Training of people is an inherent part of a project. The education of the contractors and their engineers, and of the subcontractors' engineers is an essential part of the job. If you look at it from that standpoint, then you go at it yourself and solve your own problems.

The Naval Reactors Branch was faced from the beginning with two alternatives in its procurement of technical personnel:

(*a*) To lure them away from other nuclear programs; or

(*b*) To train its own personnel.

To lure people from other programs would not have enhanced the Nation's potential in this field. Therefore, it was decided to train personnel for this program in all of the necessary basic fields and specialties.

Special lecture series and courses were arranged at each laboratory and shipyard. Universities near each activity have been utilized for pertinent academic training. Personnel of the Naval Reactors Branch themselves have actively participated in the technical training of the activities doing work for us. By means of these programs, many hundreds of scientists, design engineers, plant operators, medical officers, and maintenance personnel have been trained in nuclear specialties. The training program is expanding to keep pace with the increasing development and construction requirements.

I would prefer, if this is agreeable to you, sir, to address myself to the specific case where a very large program such as the naval program has been able to "make" its own people. I think this is somewhat different than the testimony you have been listening to.

I fully agree that there is a great shortage of scientists and engineers in the United States; in fact, the only avocation I have permitted myself over the past few years is to do what I could to help alleviate this shortage.

For example, in an address entitled "Engineering and Scientific Education" which I delivered at the Thomas Alva Edison Foundation last November 22, and which is made a part of this testimony as an appendix (p. 469), I advanced the idea that industry should help support our schools. That is all right for a long-range standpoint. But one can solve a lot of his problems by going at it himself, and not merely bewailing the horrible situation that exists. Instead of wasting time in this way, he can do something constructive about it.

Mr. Price, I am sure that Mr. Van Zandt and you know the spirit in which I am talking here.

With your permission, I would like to tell you a few of the things that we have done.

Representative PRICE. Would you proceed with your prepared statement?

Admiral RICKOVER. I would like it understood that any statements that I make today in answer to questions your committee asks will be my personal views and not necessarily those of the Atomic Energy Commission or of the Navy Department. I am sure that you can obtain the official views of the Atomic Energy Commission and the Navy Department by asking for them. On this basis, and with your permission, I will proceed.

I have brought with me a number of documents. They contain specific items which describe what has been done along the educational and training lines by every contractor, shipyard and Navy yard in the naval reactors program, how many people they have trained and are training, how they go at it, and how many hours are used. You can see this adds up to a considerable total of education and training for our program.

In any technical field the man in charge must himself assume the responsibility for training his own people and those of the contractors and subcontractors. There are very few engineers and scientists available for hire who have training or experience in the design of nuclear powerplants. Experience with reactor studies or with the design of research reactors or plutonium production reactors is of only minor value to the designer of a nuclear powerplant. Therefore, since one cannot recruit experienced nuclear engineers he must train his own.

I decided from the very beginning to train the people in my own organization and to arrange for the training of those in the contractors' organizations also.

As personnel within the Naval Reactors Branch became trained in nuclear engineering, they gave several series of technical lectures to top management and engineering personnel of the first contractors in the naval reactors program. The Bettis Laboratory, which the Westinghouse Electric Corporation operates for the Atomic Energy Commission, for example, employs many people whose sole purpose is to train subcontractors to become qualified in the highly specialized work we are doing. Many of the subcontractors have not previously had to do work requiring so high a degree of engineering skill and accuracy, and they have to be trained for it; they nevertheless continue to make many mistakes so that the training never ceases.

Similarly, the Electric Boat Co., being the first shipyard to acquire competence in this field, has been used to train personnel of other shipyards as they enter the field.

We have also arranged for training of people in the Knolls Atomic Power Laboratory, operated by the General Electric Co. for the Atomic Energy Commission. At the present time we are doing the same for Combustion Engineering, Inc., which was recently selected as the third contractor for designing naval nuclear propulsion plants. We have also trained a number of shipyards and Navy yards.

The first thing we did along this line was to arrange to have set up for naval officers a special 12-month course of instruction in nuclear engineering at the Massachusetts Institute of Technology. These officers were either graduates of the Naval Academy or were engineering graduates of civilian universities. All had received 3 years of postgraduate work in engineering prior to being assigned to the nuclear engineering course at MIT. The special course at MIT was started in 1949.

Later in 1949 I was instrumental in establishing the Oak Ridge School of Reactor Technology for the purpose of giving advanced nuclear training for members of my own organization, Atomic Energy Commission contractors, governmental agencies, navy yards, and shipyards. We have a large number of people in the field of nuclear power who have graduated from MIT and from the Oak Ridge School. These schools were established to get into the hands of future reactor designers information which existed at that time mostly in classified form in the minds and notebooks of Manhattan project scientists and engineers. Many of the senior technical personnel of the Naval Reactors Branch and its contractors received their first nuclear engineering education at one of these courses.

Three points can be noted from these programs:

(*a*) They create new nuclear engineers rather than attempting to lure existing ones from other Government atomic energy programs.

(*b*) Most of the cost of this training is being borne by the companies involved, and not by the Government.

(*c*) A very real sacrifice is made from the very beginning of each project to divert a significant fraction of the senior scientists and engineering personnel for long periods of time into training; first learning, then teaching.

On top of that, I require all of the young engineers who join my organization, despite the many hours of overtime they put in, to take night college courses. The various laboratories working on our program also give a large number of courses to their own scientists and engineers.

If you glance through these documents, you will see to what extent this is being done.

Representative PRICE. We have a quorum call in the House.

Admiral RICKOVER. I think that I can complete my statement in a few minutes. The main aspect of these documents is that they contain no generalities. You can see from the documents exactly what sort of training we are giving: the number of people involved, the duration of the courses, what contractors, shipyards, or navy yards are involved, etc.

Representative PRICE. Let me ask you this question: if you were faced with the responsibility of setting up your office today and going into some new projects and you did not have the organization you have had working with you for years, would you not be in quite a quandary

as to where you were going to find the scientists and engineers you would need?

Admiral RICKOVER. No, sir; I would not be in a quandary. When a qualified man is placed in charge of a worthwhile project, and one which people consider important, he can attract two or three good men to start off with; these in turn attract others. Then you start intensive training. The selection and training of personnel is the single most important part of a leader's job, and it is one which he cannot delegate, but must do it himself.

The situation you mentioned is exactly what I faced. When I started off there was no one but myself.

Representative PRICE. Do you have any idea as to where the nub of this problem is of training and producing for the future more scientists and engineers.

Admiral RICKOVER. Mr. Price, in the type of culture we have in the United States today, you get the kind of people you pay for. Of course, there are dedicated people in every profession, but not enough to carry the profession along. If you would immediately double the salaries of teachers, you would immediately start attracting better people to the teaching profession.

I know many scientists and engineers who would rather teach than work in industry. They are highly qualified to teach and would do so provided they were given a salary which would enable them to maintain their families decently, in the same manner their friends in industry do.

Unless we quickly remedy the present treatment of our teaching and scholarly resources we will inevitably have morally and intellectually incompetent teaching staffs. Eventually the bright young man will sacrifice his desire to teach in favor of an adequate standard of comfort, decency, and security for his family. The movement away from teaching has actually begun, and it looks as though it will continue at an increasingly rapid rate.

Unless you raise teachers' salaries to comparable industrial salaries you are going to remain in this quagmire. Increasing salaries is the most important thing to do, and it should be done at once.

Another thing I would do is increase the length of the school year. The Russians have school for about 10 months each year, and a 6-day school week. With good teachers, proper teaching methods, and about 210 days of schooling per year, I am convinced that we could have the majority of our children getting out of high school and able to enter at least the second and probably the third year of college.

This improvement in teaching and increase in length of the school year is going to be extremely important from now on because of the increase in our youthful population and the increasing shortage of school facilities.

Another thing that I would do immediately is to set up demonstration college preparatory high schools in about 20 or 25 centers in the United States. I think that some of the foundations, such as the Ford Foundation, and industry might be interested in this. These schools would be started and run for a 5- or 6-year period; they would be staffed by the foundations with suitable teachers who would be paid salaries commensurate with those being paid in industry. No tuition would be charged.

The pupils selected for these schools would represent a cross section of the community, and not only the bright ones. The school year would consist of about 210 full days per year.

These demonstration schools would serve as a living example of what could be accomplished by good teachers, a proper curriculum, and an adequate school year.

I am convinced that great improvement in high-school education could be effected in this way. I know that many children are being held back by inefficient schools, crowded classrooms, and inadequate teaching.

Representative PRICE. You feel for a science teacher at any level, high school or any level, they have to keep abreast of matters of science and probably through seminars and summer courses and so on. Is that not the custom in most school systems, that the teachers not only in science, but almost any other subject, are required to take certain summer courses?

Admiral RICKOVER. It is generally left up to the teachers themselves. The reason many of the teachers take the summer courses is because it enables them to get promotions in the schools. However, many of them do it on their own time and for self-improvement.

But what we need is a much higher level of ability in teaching than is presently the case in many of our schools.

You see, the Russians have a much simpler system. They decree that only one-third of the high-school graduates will go to college—those who are the best. We don't and can't have any such decree in the United States. So the boys and girls in Russia must study hard to get into college, and therefore only the best ones enter.

In this connection, however, it is my opinion that in addition to putting stress on better teachers, better curriculum, and a longer school year, some careful thought should also be given to the necessity of instilling in the boys and girls, early in their school years, the vital importance to their futures, as well as our country's future, of the necessity for each one of them to receive the best education he can possibly obtain. We must see to it that every high-school boy and girl who has the talent is encouraged to take the proper courses and work hard so that he will be qualified to go on to college. The ability of our youth must not be permitted to waste away. It is up to us to see that every student who has the ability to enter college does so. We simply cannot afford to waste potential talent.

The Russians have created a definite incentive and inducement to study hard in high school which does not, generally, exist in the United States. Their objective is to achieve the scientific and engineering leadership of the world.

We have known for several years that our scientific training has been deteriorating, and have done little about it. The first step we must take is to improve the technical and scientific training of our young people.

I suggest that industry, at its own expense, lend its engineers for a year's teaching service in our schools—as an emergency measure to offset the present critical shortage of teachers, especially in mathematics and science. I also suggest that a clearinghouse be set up to receive and channel all contributions by industry to colleges and universities, and that industry recognize the need to increase such contri-

butions substantially and consider this as part of the expense of running the business; that the length of the school year be extended from 180 to 210 days to bring it more in line with the school year in Europe and Russia; that extraordinary pains be taken from now on to seek out and cultivate our gifted children; that two different kinds of high schools be set up, one having higher standards, to enable our gifted youth to advance as rapidly as they are able to, unhampered by the slower rate of the children whose abilities lie in other fields than the academic.

Representative PRICE. Admiral, this is rather embarrassing because we would like to hear more at length from you. I wonder if you could possibly come back this afternoon.

Admiral RICKOVER. I could come back this afternon if it is convenient to you, sir.

Representative PRICE. Would you return, please, at 2 o'clock?

Admiral RICKOVER. Yes, sir.

I want to show you some of the things I have here.

Representative PRICE. We would like to hear from you, but we have a quorum call.

The committee will stand in recess until 2 o'clock this afternoon.

(Thereupon, at 12:30 p. m., the committee was recessed, to reconvene at 2 p. m., same day.)

AFTERNOON SESSION

The committee reconvened at 2 p. m., upon the expiration of the recess.

Representative PRICE. The committee will be in order.

We will again hear from Admiral Rickover, head of the Naval Reactors branch of the Atomic Energy Commission.

Admiral Rickover, you had started to testify in the morning session and so I know you are familiar with the subject the committee is exploring.

I am just wondering whether you would express yourself as to what you would do about attempting to solve this problem of a shortage of scientific manpower. For instance, what would you do immediately, then possibly, what you might do on a long-range basis to help to try to solve this problem.

STATEMENT OF REAR ADM. H. G. RICKOVER—Resumed

Admiral RICKOVER. There are 2 or 3 things I would do immediately. Just before adjournment I touched on the matter of demonstration high schools. I would try to enlist the aid of a number of foundations, such as the Ford Foundation, and industry to set up about 20 or 25 demonstration high schools in various places in the United States. These high schools would be, definitely, college preparatory schools. They would be operated privately by the foundations, and they would be set up for a period of about 5 or 6 years.

They would charge no tuition, but at the same time they would not let the parents or the public authorities determine what the curriculum would be or how the schools operated. Their standards would be so good that there would be no necessity for outside interference.

They would pay their teachers at the going rate in industry because, as I mentioned this morning, I know personally that there are many

engineers and scientists in industry who would much prefer to teach rather than to be in industry, provided they are given a decent salary, one which would permit them to maintain their families properly.

The type of building for these schools is unimportant; in fact, it could be demonstrated that you could use old buildings and that teachers are far more important than buildings.

As I said, these schools would be operated on a college preparatory basis, with teachers' helpers and with other educational aids. If we ran these schools for 210 days a year instead of about 180, as is presently the case, it is my firm belief and conviction that children, after attending 4 years in schools of this type, would be ready to take either the second or third year of work in college.

These schools would constitute a living example to the community as to what could be done. This demonstration high-school program is something which could be started immediately.

From a long-range standpoint, I think the quickest solution is to considerably increase the salaries of teachers, perhaps to twice what they are now. It is true in every occupation that, even though there are a good many dedicated people who work hard without regard to salary—and there probably are more dedicated ones in the teaching profession than anywhere else—by and large in an economy and in a culture such as ours, the people who go into a given profession are just about worth the salary they get.

Now, what sort of teachers we get will depend on what the community thinks of education and what the community is willing to pay for it. If the community thinks that education is one of its most important functions, and if the parents consider that the training of their children is more important than the clothes they wear or their entertainment, we will get better schools and better teachers.

Therefore, I firmly believe that the immediate step which must be taken is to increase amply the salaries of teachers. If we do this and use some discrimination along with pay increases, we can also weed out unsatisfactory teachers.

I would make the teaching profession the most respected and honorable one in our land and one into which people desired greatly to enter, and not one to be used as a temporary convenience, as is sometimes the case.

I am sure that in almost any community in the United States if the proper steps were taken to show the parents what the children are missing by inadequate education, they would loyally support schools to the necessary extent.

Representative PRICE. You have a question, then, of local responsibility.

Admiral RICKOVER. I think that it should be more a matter of local responsibility. I think ultimately if you have the Federal Government taking over all of the education, then the Federal Government starts controlling it. I think the Federal Government can help education, but it would be best to have the major support come locally.

Representative PRICE. In what way do you think that the Federal Government could participate in the training program?

Admiral RICKOVER. I think the Federal Government could participate to this extent: It could designate some disciplines or subjects which are considered to be very important from a national standpoint, and which need enhanced attention.

The Federal Government could make up the difference between the current salary teachers are getting in their community and what the going rate is in industry. This difference in salary would be paid to those schools who demonstrate that the teachers of the particular subject can teach it to the standard set by the Federal Government.

You might set up physics, mathematics, and chemistry this year as federally assisted subjects; 3 years from now it might be Russian, French, and biology.

The Federal Government could designate which subjects they consider of immediate importance for the national welfare and subsidize the pay of teachers to the extent that it equals the going rate in industry. This will get better teachers into the schools.

This should be a temporary measure. I believe there is a precedent for this procedure, such as Federal support of State roads, and in existing legislation which provides for Federal assistance in teaching of vocational subjects. The Smith-Hughes Act was enacted by Congress in 1917 to promote vocational education of less than college grade under a cooperative arrangement between the Federal Government and the States. The act provides annual appropriation for the States for education in agriculture, home economics, trades, and industry.

This act certainly could be used to assist in science, mathematics, languages, or other education.

Representative PRICE. The Atomic Energy Committee last year set up this study group to study the impact of atomic energy on the Nation's economy. That, of course, helped to stimulate the interest in participation of private industry in the atomic energy program.

What has been the impact of this new industrial participation program on the use of scientific and engineering manpower?

Admiral RICKOVER. To a great extent the companies getting into the game are trying to proselyte people from existing organizations. I think it is very foolish of them because some of the people they proselyte in this manner are not really the best people. They may have reputations, but they are not really the people who can design reactors.

As I stated this morning, I think that anyone who has charge of a project, and I am talking obout power reactors because I am more familiar with that, ipso facto assumes the obligation of training his own people and training the people in the particular industrial organizations that work for him.

We have done this in the naval program, and how we have done it is outlined in these voluminous documents. They contain actual statitics that cover a period of several years; they show what we have done to train people in various disciplines and in various vocations, exactly the kind of courses we have fostered, and how many people have taken them. By and large they have been paid for by the companies themselves and not by the Government.

Representative PRICE. Have you found any inclination on the part of any industry interested in the power program to sort of stockpile scientific and engineering personnel they would have need of?

Admiral RICKOVER. No, sir; I have not found that at all. I don't think that this is true in any segment of American industry. There are places, however, where scientific and engineering personnel are not being used efficiently.

Representative PRICE. They are utilizing all of the manpower that they are getting now?

Admiral RICKOVER. Yes, sir.

Of course, you know that there is a great shortage of scientific and engineering personnel. We can help alleviate this shortage by instituting the type of training where those who are responsible for programs make it a specific part of their jobs to train people.

There is another general thing that could be done and that is to increase the efficiency of engineers. In some industrial organizations they do not worry too much about the number of engineers they have doing the job. Having more engineers on a job than is necessary tends to ruin them, because it is not good for any man to be engaged in work which does not tax his brain.

In my opinion, we could increase the efficiency of the engineering personnel in this country by about 40 percent by proper use of our engineers, by not having them do things which engineers should not do, and with other, lesser trained, people can do.

Another thing which can be done: I recently visited a large metallurgical organization where the management was complaining about their inability to hire metallurgists. As you know, last June only some 500 were graduated in this country and in Canada. The management could have taken local boys who work in the plant and given them night courses in metallurgy, and in 2 to 3 years they would be able to do a considerable part of the work usually done by a metallurgist. It is not too difficult to run tests on metallurgical samples. Not enough of this night training of high-school graduates is being done.

Representative PRICE. Could you give us an example of how you train people who have degrees in engineering or science to perform the functions that actually are technical in their makeup?

Admiral RICKOVER. I will pick one example at random from the lists I have here, although it applies to a number of activities that I am concerned with.

At the Electric Boat Co., for example, among other training they have night courses for draftsmen and workmen. If these men complete the course successfully the company pays the tuition. That is how the company creates its own draftsmen and this is how they train people to do engineering work.

In other words, their attitude is, "We have a job to do, and we will do it ourselves, and not depend on someone else to do it for us." This example for Electric Boat is true of all the contractors in the naval program.

Representative HINSHAW. I think that the program instituted by Admiral Rickover in the Navy in connection with the submarine-type reactors in particular, and the success in recruiting crews who were competent, and we have reason to know they were highly competent, has been outstanding.

I think the gentleman and his group in the Navy are to be highly congratulated.

The work of that group in preparing training courses and in training men, I think, could probably form a basis upon which similar training courses could be based throughout the United States.

I note that in the literature which has been furnished us there were two types of courses of instruction; namely, the type given to enlisted

men who were well qualified for the job they were doing, but probably did not have an extensive education, and then for another part of the course it was for officer personnel and such other personnel as were able to take this additional work.

I think it is an excellent system.

Admiral RICKOVER. Wherever we find an enlisted man who has the aptitude to do the same work as the officer, we put him into the same school class as the officer. Our greatest loss in this program is enlisted men becoming officers. The proportion of enlisted men in our program who have become officers is many times that in any other part of the Navy. In much of our training the officers and the enlisted men are in the same group.

I don't regret the large number of enlisted men who become officers and are thus lost to our program, because ultimately this promotion redounds to the benefit of the Navy and to the country.

I would like to show you 1 or 2 instruction books used in naval nuclear power training, if I may. This book is called Reactor Compartment Auxiliary Valves, and can only be issued to members of the military service because it contains defense information. It is one of a series of more than 100 volumes which we have prepared for a submarine nuclear propulsion plant.

I will show you some more of a different series. Here is one of another series of six volumes. It is called The Manual for Power Plant and Supporting Auxiliaries, and if you will glance through it you will see what an extensive volume it is.

And here is an Operator Training Guide. An examination in it must be taken before a man is qualified as a reactor operator for a naval plant.

Representative HINSHAW. This book, Admiral, is on reactor compartment auxiliary valves. Does that include those special valves that had to be designed especially in connection with reactors on board submarines?

Admiral RICKOVER. Yes. You can see what a tremendous amount of work has gone into it.

Representative HINSHAW. We remember your telling us some time ago that these valves had to be asolutely perfect in their operation, of course, because none of the materials that passed through the valves could be allowed to escape into the air of the submarine, otherwise service aboard the submarine might be lethal.

Admiral RICKOVER. That is correct, sir.

Representative VAN ZANDT. Admiral, this training program that you are speaking about now, does it involve the training of personnel for the manning of these additional yards to give them the potential of nuclear construction?

Admiral RICKOVER. Yes, sir. You will find outlined in these documents which I have given to you specific descriptions of the courses, the number of people that have taken them, what school or university they go to, how they get their training, and who pays for the courses.

I have tried to avoid generalities in these documents so that you can see what can be done for a specific program such as the naval program. I would highly commend to anyone else who has a program of similar magnitude to do some of these same things.

We have paid dearly for this in the time and attention it has required, and it has taken a lot of sweat to get these things done, but it has been very much worthwhile.

Representative HINSHAW. That presents an idea, Admiral. Is it possible for a young man, say, to join up in the Navy and request and receive assignment to one of these projects?

Admiral RICKOVER. No, sir, not at the time he enters the Navy, but it is possible later on. About every 3 or 4 months we issue a request for both officers and enlisted men to volunteer for the program. We do this for submarine and for surface ship personnel. The officers' records are very thoroughly screened and the best ones are interviewed in Washington to see if they are satisfactory for the program.

We are currently selecting officers to start training to operate the nuclear-powered frigate and the aircraft carrier. We must get people who are not only smart, but whom we think can become dedicated to the job, because the consequences of getting the wrong kind of people are too serious at this early stage of our program.

As far as the enlisted men for submarines are concerned, they are selected by their commands. The commands select their best people; they must already be qualified in submarines.

For surface ships we also try to get the best enlisted men for our training program.

We put the enlisted men through such stiff instruction that we have high-school graduates who are able to pass college sophomore examinations in physics at the end of about 3 months.

Representative VAN ZANDT. Admiral, in the manning of these yards, to give the Navy this nuclear potential that it must have in ship construction, has it been necessary to raid any of your existing projects for personnel?

Admiral RICKOVER. No, sir. I do not permit anyone of our contractors to raid any other of our contractors. That is one of the sine quo nons. If a contractor gets into the naval reactors program he is not allowed to hire scientists or engineers from any other organization in our field. He must train his own people. Otherwise, he is not contributing anything.

Representative VAN ZANDT. In other words, then, this training program that has been put together is functioning to the extent that it is furnishing adequate personnel as the yards expand to meet the needs of the Navy.

Admiral RICKOVER. Let me give you a couple of examples.

When we started out with the Electric Boat Co., they had about 10 engineers; now they have about 350, and these are not people that they have obtained from other atomic activities. These are people that have been trained by Electric Boat.

The Newport News Shipbuilding & Dry Dock Co. now has about 60 to 70 engineers in their nuclear program, and this does not include draftsmen who have been and are being trained in this field, but not a single engineer was not trained at the company's own instance, either by sending them to Oak Ridge or to some other school, or else trained at one of the laboratories employed in the naval program. Not a single one of these engineers has been taken away from another atomic activity.

I want to make this point clear, because I consider that everybody in the nuclear power field should do the same.

Representative HINSHAW. Then at that rate, for those who hope to have power reactors on a large scale, or to engage in the construction of power reactors, they ought to be starting now to train their engineers?

Admiral RICKOVER. Yes, sir.

Representative HINSHAW. Or to retrain them?

Admiral RICKOVER. Yes, sir; you will remember I have never come to your committee and complained about not having enough engineers and scientists in my program.

Representative HINSHAW. I can't remember that any complaint has ever been made by him on personnel. That is a kind of a remarkable thing, Mr. Chairman.

Representative PRICE. Yesterday the Commission testified, Admiral Rickover, that it gets about 25 percent of its annual requirement for new blood in reactor technicians.

Does that reflect itself in any way in the power reactor program, do you know?

Admiral RICKOVER. It doesn't reflect itself in my program, sir. I am not too familiar with what is going on in the other programs.

Representative PRICE. They say that they need about 2,000 new reactor technicians a year, and these would be engineering or scientific graduates and they require about 2,000 a year and they are able to get only about 500 from all sources.

Admiral RICKOVER. Well, Mr. Price, what they are saying, and it is true, is that there is a vast shortage of engineering and scientific talent in the United States. There are two ways of solving the problem:

One is to take the long-range viewpoint and the other is to do something yourself right away.

Representative PRICE. And you have already discussed that and you have given us your idea as to what you would do on the short-range immediately.

I do not remember your views on what you would do on a long-range basis.

Admiral RICKOVER. On the long-range basis, I would definitely try to have two different kinds of high schools, one which is definitely a college preparatory school such as nearly all were up to 1917 or 1918. We should have examinations and permit only the better students to enter the college preparatory-type high schools.

Those who desire to go on to college should go to the tougher high schools. The other schools would be for children whose parents went them to learn trades. These schools could also teach tap dancing, wallpaper hanging, and similar subjects.

I think that is a perfectly democratic procedure, as long as everyone has an equal chance to enter either type school. Not everyone can become a Congressman, either, you know; only a few people can.

Representative PRICE. One from each district.

Admiral RICKOVER. That is right.

Representative VAN ZANDT. This special school that you have in mind, would it be in physics and chemistry?

Admiral RICKOVER. Yes, sir. I would let a group of educators set up the course with the idea of cutting out about 2 years of the combined high school and college time. We must do so because, at the rate our population is increasing, particularly the population under

16 or 17, we are falling more behind all the time in our high school and college teachers and facilities.

Representative VAN ZANDT. Would you make a part of every school system of every community that thing, or would you centralize it in an area?

Admiral RICKOVER. I would have it in about 25 different areas in the United States. To do this right it would have to be set up with private support initially, so I figure roughly that it would cost, over a 5- or 6-year period, a total of about $250 million for 25 demonstration high schools. I think that you could get support of this idea.

Another way to help improve our high schools is to have the Federal Government step in and pay the differential in salary which is required to attract and to retain teachers qualified to teach subjects such as physics, mathematics, chemistry, and so on, for which there is presently insufficient or inefficient training.

We have got to find some means of being able to do the equivalent of what the Russians do with their authoritative system. They only permit one-third of their high school graduates to go to college. They have tough exams and the kids have to work like hell to get into college.

In this country they don't have to work hard and the school year is not long enough for present day needs. By setting up these demonstration schools and showing the parents what can be done, I think they will become strong advocates for improved high schools and insist that all high schools in their community match the demonstration schools.

Representative VAN ZANDT. Admiral, why could you not set up such a school on the campus of the Pennsylvania State University where they have the reactor, and let the Government go in there and build the facilities?

Admiral RICKOVER. You are talking about a high school now?

Representative VAN ZANDT. I am talking about this special type of high school.

Admiral RICKOVER. I think the minute you have the Government setting up this demonstration school you have Government control. I don't think that is good. I believe that most of the financing can be done by the communities themselves, and I think the most important responsibility that parents have to their children is to educate them adequately in accordance with today's requirements.

I think that the reason parents do not fully realize that their children are not being educated as well as they should or could be is because they are surrounded by a mass of propaganda about good living, social life, and so on. The ability to obtain things easily is being stressed more than the responsibilities which are inherent in being a member of a democratic community.

I don't believe that it is the function of our schools to take over all of the responsibilities of the home. I think the major function of the school is to teach fundamentals. We cannot expect our overworked school system to relieve parents of all their responsibilities.

Representative VAN ZANDT. These 25 centers that you speak about, what would their annual production in manpower be each year?

Admiral RICKOVER. They might eventually turn out about 1,000 students a year per school.

Representative VAN ZANDT. Each, or the total?

Admiral RICKOVER. I mean per school. The main object would be to have a living example of what can be done. We can't do it the way the Russions do, and we can't say, "If you don't go to college you have got to go into the Army." We can't do anything of the sort, and we should not do it.

Representative HINSHAW. I think perhaps the public is not well enough informed today over the amount of technology that the child of the future is going to have to learn. When you stop to think that electronics is assuming such a high importance in our lives, we know that, but we do not realize how really important it is.

Then, of course, the nuclear energy as a source of energy and as a source of experimental knowledge through the use of radioactive isotopes is another subject which we are only on the fringe of.

Admiral RICKOVER. I would say this, Mr. Hinshaw, that I don't think the parents appreciate how much potential their children really have to master all of this knowledge, and at a very youthful age. I don't think that as a Nation we know the vast potential of the human brain, and we make very little use of it. I know that we can do much better.

We have been talking about high schools, but perhaps the grammar schools are even more important. We must start with the high school's first, because by the time the young men and women get to college they are able to do some thinking and judging for themselves, and are able to act with some degree of personal responsibility.

We should concentrate on the high schools now, but I think ultimately it may be even more important to have our best teachers in the grammar schools.

Representative PRICE. Admiral, just the mere setting up of the training courses that you have, that in itself increased the demand for college men trained with degrees in the various sciences. While the courses that you have will train some of them in this field, that, nevertheless, trains only the group of workmen who in the future must be highly trained and technical.

It does not immediately answer the problem of getting this nucleus of the engineers, and the degree men.

Admiral RICKOVER. We took college graduates and trained them in these specialties. In my opinion, the colleges should not attempt to train specialists. The time that the young people spend in college is too short. They should be taught basic principles and not a collection of facts which are obsolete even before the students graduate.

No matter what your job is, whether you want to build a missile or an atomic reactor, or a motor, it is up to the technical organization that employs the college graduates to train them in that specialty. We have taken young college graduates into our program and trained them in our specialties.

Representatives PRICE. The courses that you were talking about did more than train just mechanical men?

Admiral RICKOVER. We trained at all levels. And we trained from operators of powerplants to physicists and to metallurgists, in all specialties. You will find that outlined in my statement.

Representative PRICE. You are adding to the pool of scientific and technically trained people?

Admiral RICKOVER. Look at it this way, Mr. Price: I think that probably not more than 1 percent of all the scientists and engineers—

and there are now about 2,000 in our program—were obtained from other atomic activities. All of the remaining 99 percent had to be trained by our organizations. We had to do it ourselves.

I would rather take a young college graduate who has only been taught principles. I would much rather have a man of that kind than somebody who has been taught the details of how to run a pump or a motor. If the young men know principles, we can take them and train them ourselves. I am sorry I did not make that clear.

We not only train enlisted men and officers, but we train scientists and engineers, too. We are training at all levels all of the time.

If you get a chance to look through these documents, you will see that we have many schools going on right now—all of the time—in various places.

Representative PRICE. The point I was getting at was whether or not that was an increase of the manpower school, scientific and engineering manpower pool, or whether those figures are already considered and they were found lacking.

Admiral RICKOVER. I don't think our program is increasing the scientific manpower pool very much in actual numbers. The important thing in science and engineering is not entirely in numbers; what is important is the ability of the individuals who are in a given field. We are definitely enhancing the ability of the people in the program to do their jobs. We are also increasing their number to some extent.

Representative VAN ZANDT. I would like to review this proposal of yours as concerning the high-school boy. As I understand, you would handpick the sharp boys in a high-school class and after setting up these 25 centralized schools, you would send these sharp boys there; is that right?

Admiral RICKOVER. Relative to these demonstration schools, I wouldn't go too far at the beginning, Mr. Van Zandt, because you might get some public opinion against you. Today, when we set up these two types of high schools it would be easy to say, "Well, we will have city wide examinations, and those who come highest in the examinations can go into the demonstration schools".

But for these schools to get a good start and receive public acceptance I would take more of a representative group of students, because my basic idea is to have all out high schools eventually reach the standard of the demonstration schools.

If they started with being too highly selective, they would be accused of being just for "eggheads".

My object is to demonstrate that most students could be motivated much better than they are now—that they can do far better than hey are doing now.

Representative HINSHAW. In my part of the country we have two kinds of high schools. One of them is a so-called technical high school, which is really a manual training high school, for those who probably are not inclined mentally so much as they might be.

Then the other school is for the balance of the people.

I have always thought that the technical high schools, so-called, were for the backward mentally, but capable manually.

Admiral RICKOVER. They were for people who didn't care to go on to college. That is the Gary system which was started by Dr. Wirt, I think, in 1907. But this system of having special high schools for teaching trades died out to a great extent after World War I. The

high school changed its character from being purely a college preparatory school and gradually became a combination of college preparatory, trade school, and social institution. In this process the college preparatory part of the curriculum necessarily suffered, and this is one of the main reasons for our present difficulty.

Representative HINSHAW. I take it that you do not go in for progressive education.

Admiral RICKOVER. I don't want to get into that argument, sir. I am only a naval officer.

Representative PRICE. Are there any further questions?

Representative VAN ZANDT. Now, you have suggested that this program should be financed by business, did you not?

Admiral RICKOVER. By business and foundations.

Representative VAN ZANDT. And cost approximately $250 million a year?

Admiral RICKOVER. Not for a year, but for the 5- or 6-year period necessary to carry through a thorough demonstration. My idea would be to get them a good enough start that the communities themselves would take over and carry on.

I also believe that business should assume a much greater responsibility for financing education because, after all, they get all of these young men and women who are now trained at public expense. I think that they should consider it as a part of the expense of operating a business. They have to pay to train their workmen to do jobs; why shouldn't they contribute to paying for the scientists and engineers they get from our colleges?

Representative PRICE. Are there any further questions?

Thank you very much, Admiral Rickover. The committee always appreciates your very frank and open discussion of these subjects, and it is the reason you have been most helpful to us in the past, and I am sure that you have been here this afternoon.

Admiral RICKOVER. I appreciate very much talking to your committee. I fully realize the problem your committee faces. Everybody has been talking about this subject, but very little seems to be getting done.

Representative PRICE. There is very little being done about it.

Admiral RICKOVER. I think there has to be a lot of initiative by those who hire scientists and engineers, and not a lot of moaning that nothing is getting done.

Representative PRICE. Thank you very much.

Mr. DURHAM. I am sorry that I was a little late in coming to this meeting, but I was attending to action on the floor of the House. I wanted to ask the admiral one thing:

Having had quite a bit of experience with the lack of scientific personnel, and also dealing with a lot of scientific problems, what is your thought of going to a selective basis at this high-school level?

Admiral RICKOVER. Would you say that again, sir?

Representative DURHAM. Going to a selective basis on the high-school level. In other words, taking the boys that have promise and some ability and classifying them into different classifications, or whatever you desire to call it, but at least putting the bright boys with the bright boys.

Admiral RICKOVER. I don't think you have to go as far as that, Mr. Durham. I believe all that is necessary is to make it possible

for any child to advance as fast as his capabilities and promise permit him; one reason this is not being done in the high schools is because it is an administrative problem where they simply don't have enough people in the high schools to do the paperwork of letting people get ahead faster.

I have personally found that to be true. If you merely made it possible, any time a child, anywhere, was ready to go ahead, if you permitted him to go ahead at that time, I think that that would satisfy the proposition that you are raising. I definitely believe that gifted students should not only be permitted but encouraged to advance rapidly.

Representative DURHAM. I realize the difficulty in the type of educational system that we have at the grade level in a democracy. There is some difficulty there, but it always appeared to me that we were losing a lot in not bringing along the bright boy.

Admiral RICKOVER. If you start in segregating the bright ones by groups, I think that you may have undesirable social consequences. I think it is good for the bright students to associate with all kinds of people.

Representative DURHAM. I do, too.

Admiral RICKOVER. But I would let them go ahead faster. I think that you could solve the problems, not to the extent that you might want, perhaps, but I think that, even in balancing all of the factors, you would achieve about 90 percent of what you want if we had a mechanism where any child could advance at any time that his capabilities permitted him—if he was not held back. We must seek out and cultivate our gifted children, for it is from their ranks that creative ideas will come.

It is during the formative years that the good and the bad mental habits set in. Here are all these children, very much alive and interested, but they are not being pushed mentally by their teachers. They just sit around and dawdle and develop bad habits because they are not being challenged.

All schooling should be more difficult than the student is capable of. It should always be beyond the student. It should be a constant challenge and struggle.

I mentioned before you came in here that I though the grammar schools were even more important than the high schools.

Representative DURHAM. The boy that makes a C grade takes up as much time and effort and money on the part of the teachers as the individual who has the ability to advance in science courses. Some of them just do not have this. I realize the difficulty in our educational system.

Admiral RICKOVER. It is my feeling that you would accomplish most of your purpose by making it readily possible for any qualified child to get ahead as fast and as soon as he was able to get ahead. In fact, he should be encouraged to get ahead. There should be a constant challenge for him.

I find in my own field that I have an awful time getting bad habits out of people who have been subjected to the easy-going regime in the schools, and in industry, too. If I were to advertise for scientists and engineers I would advertise not for those who are looking for beautiful surroundings and country clubs and with "no particular assign-

ment"—and these last three words I am quoting from one of the recent newspaper ads—I would say "you will have to work like hell, you have to work many hours a week without getting paid overtime, and you will have to go to school at night in addition."

You can get a lot of good people that way. There are many people in this country who would like it; there are more self-respecting people than these who are looking for sinecures where they get paid for doing nothing but just associating with other smart people like themselves.

There are too many smart people, but not enough who work hard.

Representative PRICE. Thank you very much, Admiral. At this point we will insert the material you referred to earlier.

TRAINING OF TECHNICAL PERSONNEL FOR NAVAL REACTORS AND PRESSURIZED WATER REACTOR (PWR) PROGRAM

Statement submitted by Rear Adm. H. G. Rickover, United States Navy, Chief, Naval Reactors Branch, Division of Reactor Development, United States Atomic Energy Commission and Assistant Chief of the Bureau of Ships for Nuclear Propulsion

The Naval Reactors Branch was faced from the beginning with two alternatives in its procurement of technical personnel:

(*a*) To lure them away from other nuclear programs; or

(*b*) To train its own personnel.

To lure people from other programs would not have enhanced the Nation's potential in this field. Therefore, it was decided to train personnel for this program in all of the necessary basic fields and specialties.

This document describes how this was and is being done. Special lecture series and courses have been arranged at each laboratory and shipyard. Universities near each activity have been utilized for pertinent academic training. Personnel of the Naval Reactors Branch themselves have actively participated in the technical training. By means of these programs, many hundreds of scientists, design engineers, plant operators and maintenance personnel, and medical officers have been trained in nuclear specialties. The training program is expanding to keep pace with the increasing construction and development demands.

OUTLINE

I. Introduction.
II. Training:
  A. Atomic Energy Commission contractors:
    Bettis Plant, Pittsburgh, Pa. (operated for the Atomic Energy Commission by the Westinghouse Electric Corp.).
    Knolls Atomic Power Laboratory, Schenectady, N. Y. (operated for the Atomic Energy Commission by the General Electric Co.).
    Combustion Engineering-Superheater, Inc., Nuclear Engineering and Development Laboratory, Windsor, Conn.
    Duquesne Light Co., Pittsburgh, Pa.
  B. Private and naval shipyards:
    Newport News Shipbuilding & Dry Dock Co., Newport News, Va.
    Bethlehem Steel Co., shipbuilding division, Quincy, Mass.
    Mare Island Naval Shipyard, Vallejo, Calif.
    Portsmouth Naval Shipyard, Portsmouth, N. H.
    Electric boat division, General Dynamics Corp., Groton, Conn.
  C. Naval Reactors Branch personnel.
  D. Basic nuclear engineering education programs:
    Massachusetts Institute of Technology, Cambridge, Mass., naval nuclear engineering courses.
    Oak Ridge School of Reactor Technology, Oak Ridge, Tenn.
    Training for reactor plant operators.
    Training for medical officers and hospitalmen.
  E. Miscellaneous training:
    Reactor design and technology manuals.
    Instruction books for nuclear powerplants.
    Assistance in disassembly of Canadian and Oak Ridge reactors by naval personnel.
    Training in statistics and design experiments.
III. Recruiting of technical personnel for naval program.
IV. Maximum utilization of other skills.

APPENDIXES

1. Nuclear power school for naval operators; curriculum, United States Navy submarine base, New London, Conn.
2. Nuclear training for medical officers and hospitalmen:
   A. Scope of new curriculum for medical officers for nuclear propulsion program.
   B. Billet description of Hospital Corps personnel assigned to nuclear submarines.
3. Table of contents of some of the reactor technology handbooks prepared by the Naval Reactors Branch and its contractors:
   A. Liquid Metals Handbook.
   B. Sodium-NaK Supplement to Liquid Metals Handbook.
   C. Metallurgy of Zirconium.
   D. The Metal Beryllium.
   E. Bibliography of Available Computer Codes for Nuclear Reactors.
   F. Reactor Shielding Design Manual.
   G. Corrosion and Wear Handbook for Water-Cooled Reactors.
   H. Nuclear Plant Piping Handbook.
4. Procedure and criterion for qualification as a chief operator at the naval reactor test facility, Arco, Idaho.
5. Chart of nuclear training at the Portsmouth Naval Shipyard.

I. INTRODUCTION

There are very few engineers and scientists available for hire who have training or experience in the design of nuclear powerplants. Experience with reactor studies or with the design of research reactors or plutonium production reactors is only of minor value to the designer of a nuclear powerplant.

Therefore, since one cannot recruit experienced nuclear engineers he must train his own. These pages describe the steps taken by the Naval Reactors Branch of the Atomic Energy Commission to accomplish this within the naval reactors and pressurized water reactor (PWR: Shippingport, Pa.) programs.

The advanced nuclear engineering course for naval officers at the Massachusetts Institute of Technology (MIT) and later the Oak Ridge School of Reactor Technology were established during 1949 largely at the instigation of Admiral Rickover to get into the hands of future reactor designers information which existed at that time mostly in classified form in the minds and notebooks of Manhattan project scientists. Many of the senior technical personnel of the Naval Reactors Branch and its contractors received their first nuclear engineering education at one of these courses.

As personnel within the Naval Reactors Branch became trained in nuclear engineering, they gave several series of technical lectures to top management and engineering personnel of the first prime contractors in the naval reactors program. The Bettis Laboratory, which the Westinghouse Electric Corp., operates for the Atomic Energy Commission, became the focal point for training personnel of other organizations in nuclear engineering as they entered the water-cooled naval reactor business. Similarly, the Electric Boat Division of the General Dynamics Corp., being the first shipyard to acquire competence in this field, was used to train personnel of other shipyards as they entered the field.

In section II, part A, below, the programs are described which each of the naval reactors contractors has undertaken to develop a core of trained nuclear engineers and scientists. Part B summarizes the programs of the shipyards, private and Navy, for training nuclear engineers and designers. Part C discusses the training of the personnel of the Naval Reactors Branch itself and also lists the lecture series which they have given to various other organizations. Part D describes the basic nuclear engineering education programs such as the naval nuclear engineering courses at MIT, the Oak Ridge School of Reactor Technology, the training of naval officers and men in operation and maintenance of naval nuclear powerplants, and the training of medical officers and hospitalmen for duty with nuclear powered vessels. Part E gives some examples of miscellaneous training functions performed under the naval reactors program, such as the preparation and publication of reactor design and technology manuals, preparation of instruction books for nuclear powerplants, etc.

Three points can be noted from these programs:

(*a*) They create nuclear engineers rather than attempting to lure existing ones from other Government atomic-energy programs.

(*b*) Most of the cost of this training is being borne by the companies involved and not by the Government.

(*c*) A very real sacrifice is made from the very beginning of each project to divert a significant fraction of the senior scientists and engineering personnel for long periods of time into training; first learning, then teaching.

The training programs fall into several categories:

(*a*) Formal nuclear training at central locations such as MIT and Oak Ridge.

(*b*) Special training schools and lecture series set up by each of the various companies and shipyards in the program to cover broadly the basic principles of nuclear engineering for large groups of their technical personnel. These courses are given by the senior people in the Naval Reactors Branch, and later by senior people from various contractors in the naval reactors program.

(*c*) Special ad hoc courses established to cover specific aspects of nuclear design in detail; these include reactor design, radiation shielding, basic reactor physics, statistical design of experiments, etc.

(*d*) Academic training in the basic technical subjects (such as mathematics, physics, metallurgy, heat transfer) established with local universities and other educational facilities near each contractor. Special measures are taken by each organization to encourage such extracurricular training; for example, several of the contractors reimburse all expenses of tuition and books upon successful completion of technical courses. This philosophy has been carried even to draftsmen and technicians.

(*e*) Special technical books and reports are being prepared and published to implement the training lectures. These include nuclear design manuals and handbooks covering various fields of nuclear powerplant technology, and detailed and comprehensive instruction books and powerplant manuals prepared for each new reactor plant to insure that the reasons behind the various design features of the plant are made clear to the plant operators and to the designers of future plants.

(*f*) Since personnel enter this program with widely different specialized backgrounds ranging from shipbuilding to mathematics, special efforts have been made to acquaint these new people with the broader technical problems of nuclear power. Trips to other facilities, exchange of personnel between organizations, etc., have been arranged for this purpose.

Section III discusses briefly the recruiting, selection, and hiring practices followed by the Naval Reactors Branch in obtaining potential nuclear engineers.

Section IV mentions steps being taken to minimize the demand within the naval reactors program for nuclear engineers, by devising means to increase the use of the more available skills where possible and thus to free nuclear engineers and scientists for work for which their specialized training is a prerequisite.

II. TRAINING

A. Atomic Energy Commission contractors

This section contains a summary of the technical training programs which have been developed with the help of the Naval Reactors Branch at the Bettis plant (operated by Westinghouse for the AEC), the Knolls Atomic Power Laboratory (operated by General Electric for the AEC), the Combustion Engineering Company, Nuclear Engineering Laboratory, and the Duquesne Light Co. personnel associated with the pressurized water reactor program.

In addition to general background courses and lectures, there are several courses aimed at various specific groups and problems which are set up as the need arises, with the duration, level, and number and type of personnel attending being determined separately for each case. In many cases, personnel from several organizations within the naval reactor program attend these courses.

All of the naval reactors contractors have made special arrangements with local universities to encourage continued academic education of their technical personnel. Of particular interest in this regard are the joint fellowship arrangements which Bettis has made with the University of Pittsburgh and the Carnegie Institute of Technology.

With the exception of these joint fellowship programs, nearly all of the expenses of the training programs have been borne by the companies themselves. For example, when an organization sends a man to Bettis for on-the-job training, the company pays his salary and other expenses during that period out of company funds. Reimbursement of tuition and other expenses incurred by technical personnel for outside courses is also made by the company and not with Government funds.

The special courses given by the contractors are not casual lectures, but are planned courses with heavy homework assignments and written examinations and grades. Most of them are given after working hours and on Saturdays.

1. Bettis plant (operated for the AEC by Westinghouse)

(*a*) *Reactor engineering training program.*—The 23-week program consists of 362 hours of instruction in the following seven courses:

(1) Introduction to the nuclear reactor.
(2) Reactor plant technology.
(3) Dynamics and control of reactor plants.
(4) Heat transfer and fluid flow.
(5) Metallurgy.
(6) Materials appliaction and development.
(7) Stress and vibration analysis.

Approximately 40 persons have received certificates signifying successful completion of all of the above 7 courses. Full-time attendees spend approximately two-thirds time in attending classes and in study periods and one-third time on work assignments during the 23-week period.

These courses have been conducted as follows:

First program (November 22, 1954–April 29, 1955): Attendance, approximately 125 Bettis personnel.

Second program (February 14, 1955–July 22, 1955): Attendance, 107 Bettis personnel, 11 Navy-sponsored personnel from Mare Island, Portsmouth, Electric Boat, and the AEC Pittsburgh Area Office.

Third program (June 6, 1955–November 11, 1955): Attendance, 163 Bettis personnel, 25 Navy-sponsored personnel including Newport News, Bethlehem Steel, Mare Island, Portsmouth, United States Naval Postgraduate School, and the AEC Pittsburgh Area Office.

Fourth program (November 21, 1955–May 4, 1956): Attendance, approximately 200 Bettis plant personnel, 7 AEC Pittsburgh Area Office personnel, 18 Navy-sponsored personnel from Mare Island Naval Shipyard, Newport News, Bethlehem Steel Shipbuilding Division, and Combustion Engineering, Inc.

Fifth program will begin May 7, 1956, and will be attended by selected Bettis personnel and personnel to be trained at the request of the Naval Reactors Branch, AEC.

(*b*) *Pressurized water reactor (PWR) lectures for Duquesne Co. (April 27–September 7, 1954).*—Attended by approximately 25 Duquesne Light Co. top management and engineering personnel. Scheduled 1½ hours per week, lectures were presented by top Naval Reactors Branch and Bettis administrative and technical personnel. Topics covered included: AEC and Bettis organization, reactor types, reactor core physics and design, PWR plant design and *Nautilus* plant experience, PWR fuel elements, boilers, pressure vessels, pumps, valves and piping, control systems, reactor safeguard requirements, and shielding.

(*c*) *Duquesne Light Co. program (January 6—August 23, 1956).*—Being attended by 20 Duquesne Light Co. personnel, this program consists of 134 contact hours of instruction which include courses in Introduction to the Nuclear Reactor, PWR Reactor Plant Technology, and Reactor Plant Kinetics and Control. Thirty-six hours of instruction will be taught by Bettis personnel, the remaining hours being taught by Carnegie Institute of Technology and the University of Pittsburgh.

(*d*) *Nuclear design course (October 11, 1955–March 1, 1956).*—Attending were approximately 30 Bettis scientists and engineers, most of whom work in nuclear design sections. The course, which met 3 hours per week, dealt with specific problems and methods of solution encountered in the nuclear design of reactors, with particular emphasis on methods of solution used at Bettis. The course is taught by the manager of the Bettis Reactor Physics Applications Activity. A special supplementary course in nuclear physics of reactors was presented informally to a small group of engineers enrolled in the nuclear design course who lacked the necessary background in nuclear physics. The course was taught by the Bettis PWR Physics Department.

(*e*) *Magnetic amplifier theory course (March 28–June 27, 1956).*—Presented to approximately 30 Bettis engineers for 14 weeks for a total of 30 hours of instruction. Taught by personnel from Westinghouse New Products Department.

(*f*) *Course in design of experiments (April 7–July 7, 1956).*—Course of 2 hours each Saturday morning for 14 weeks by the National Bureau of Standards. The course is designed to develop fundamental and basic skills in design of experiments, to reveal areas of application, and to uncover specific project problems with statistical features.

(*g*) *Physical metallurgy course for manufacturing department personnel (January 7–May 19, 1956).*—Presented for 1½ hours on Saturdays to 30 quality con-

trol department and central production personnel at Bettis plant. Lectures presented by metallurgists from Carnegie Tech include selected topics in physical metallurgy from the metallurgy course which is part of the reactor engineering training program.

(*h*) *Bettis Shielding School* (*February 20–March 30, 1956*).—This 6-week school consisted of an 82-hour course in radiation analysis and shielding, a 36-hour course in mathematics of shielding design, and organized discussion periods totaling 36 hours.

Attending the school were 22 persons from Electric Boat, Newport News, Bethlehem Shipbuilding, Knolls Atomic Power Laboratory, Naval Reactors Branch, Combustion Engineering, and the Mare Island, Portsmouth, and New York Naval Shipyards, plus 11 Bettis plant personnel. Those attending devoted full time to this effort during the 6-week period.

About three-fourths of the lecture time in the radiation analysis and shielding course was furnished by Bettis personnel, the remaining by personnel from Electric Boat, Newport News, and Knolls Atomic Power Laboratory. The mathematics course included special topics in advanced calculus to provide necessary background as needed, and was taught by special arrangement with Carnegie Institute of Technology.

(*i*) *Technical indoctrination program* (*continuing*).—A 2-week orientation course for technical personnel new to Bettis plant to provide the new engineer or scientist with a background of information of technological, organizational, and procedural material essential to the operation of Bettis plant. Sessions are held each afternoon for 3 hours. First program, attended by 78 persons, began March 5, 1956. Additional sessions will be conducted periodically as needed—perhaps once per month.

(*j*) *Reactor physics and core thermal design* (*May 28–June 29, 1956*).—Full time 5-week course specifically for nuclear reactor core designers to acquaint them with reactor physics for both fully enriched cores and high uranium content cores and the manner in which physics data are applied to the thermal design of cores. Emphasis to be placed on manner of attack of problems rather than detailed calculations that have to be performed.

To be attended by approximately 30 persons from Knolls Atomic Power Laboratory, Combustion Engineering, and Naval Reactors Branch and selected students from Bettis core design groups. Lecturers to be Bettis, KAPL, and NRB personnel.

(*k*) *Doctoral and fellowship programs.*—

(i) Reactor engineering fellowship program: In cooperation with the University of Pittsburgh; 41 fellowship holders are now in the program.

Phase A of the Reactor Engineering Fellowship Program consists of the Westinghouse Design School Course (January 16–May 4, 1956).

Attended by 30 fellowship holders now on Bettis rolls. Classes are held at the Westinghouse Educational Center. At the conclusion of Design School the Reactor Engineering Program, Phase B will be presented at Bettis from May 7 through September 14.

Phase B of the Reactor Engineering Fellowship Program, May 7 to September 14, 1956, includes credit courses in Atomic and Nuclear Physics, Reactor Theory, Reactor Stress Analysis, Reactor Plant Dynamics and Control, Heat Transfer, and noncredit courses in Metallurgy, Materials Application and Development, and Reactor Plant Technology. Fellowship holders receive 14 graduate credits through the University of Pittsburg for Phase B.

(ii) Physics doctoral program: In cooperation with the University of Pittsburgh; 10 fellowship holders now in the program.

(iii) Metallurgy doctoral program: In cooperation with Carnegie Institute of Technology. Two persons are now taking this program.

(iv) Mathematics doctoral program: In cooperation with University of Pittsburgh. None yet awarded.

(*l*) *Educational assistance program.*—Under this Westinghouse program one-half of tuition is refunded upon successful completion of each approved course and the remaining one-half, upon the completion of the whole program leading to a certificate or an advanced degree.

Through this program, personnel may obtain degrees in science or engineering either on a bachelor's or advanced degree level. Through the Business and Management Program, the graduate of engineering or science can obtain an understanding of business and management fundamentals. A certificate is awarded at successful completion of the program.

Five hundred Bettis personnel have, at various times, participated in the Educational Assistance Program. Three hundred thirty-eight are now in this program. To date 18 have completed their program of study culminating in a degree or certificate. Of these, 3 have received the BS degree, 6 the MS degree, and 1 the Ph. D. degree in science or engineering, and 8 have received certificates certifying completion of the Business and Management Program.

(*m*) *Training of personnel at Bettis under loaned employee agreements.*—Since 1949 over 60 engineers from approximately 23 companies have worked at Bettis under loaned employee agreements for periods in excess of 3 months each.

2. *Knolls Atomic Power Laboratory (KAPL)*

The nuclear engineering courses taught at KAPL and the enrollment in each is summarized in the following table:

Year	Course title	Class hours	Enrollment
1946–47	Nuclear engineering:		
	Advanced course	140	40
	Project course	44	
1947–48	Nuclear engineering project course	44	63
1948–49	do	44	56
1950–51	Nuclear power course	36	100
1951–52	Nuclear engineering course	98	16
1953–56	Nuclear engineering	120	28
	Engineering orientation (KAPL naval projects)	30	105
	Nuclear powerplant engineering	56	19
	Introduction to nuclear engineering	32	60

Specialized technical courses

Year	Number courses	Enrollment
1952–53	5	42
1954–55	15	75
1955–56	17	217

College reimbursement courses

Year	Enrollment
1952–53	22
1953–54	53
1954–55	51
1955–56	127

The KAPL technical training program for April 1955 to April 1956 is tabulated on the next page.

The following nuclear training program is planned by KAPL for beginning in the fall, 1956:

Course title	Prerequisite	Approximate length
Introduction to nuclear engineering	Scientific or engineering degree	16 weeks at 2 hours per week.
Materials for nuclear power	KAPL introduction to nuclear engineering.	12 weeks at 2 hours per week.
Heat transfer in nuclear power plants		16 weeks at 2 hours per week.
Shielding of nuclear power plants		10 weeks at 2 hours per week.
Reactor controls		10 weeks at 2 hours per week.
Nuclear power plant instrumentation		6 weeks at 2 hours per week.
Design considerations for marine nuclear power plants.		10 weeks at 2 hours per week.
Fuel processing and reprocessing		10 weeks at 2 hours per week.

These courses encompass approximately the same material as in the current nuclear powerplant engineering course. Homework is required in all courses.

KAPL technical training program from April 1955 to April 1956

Type	Course title	Hours	KAPL students enrolled	Remarks
Specialized technical courses	Fundamentals	52	52	Given outside working hours for engineering supporting personnel.
	Materials and process	52	43	
	Product design	52	17	
	Technician	52	6	
Specialized technical courses	Electronic circuits	52	7	Given during working hours for engineers.
	Engineering analysis I	90	9	
	Heat transfer	36	12	
	Numerical analysis	36	17	
	Servomechanisms	54	8	
	Engineering analysis II	90	1	
	High polymer	104	1	
	Statistical analysis	36	4	
	Vibration	32	1	
Advanced engineering program	First year	120	1	Given during working hours for engineers.
	Second year	120	1	
Manufacturing	Methods engineering	40	15	Given during working hours for methods and planning personnel.
	Principles of manufacturing engineering.	54	12	
Tuition refund program with colleges.	Various courses, mostly college credit technical courses.	------	57	Fall, 1955, semester, spring, 1956, semester outside working hours.
Courses developed at KAPL	Engineering orientation	------	105	A 30-hour survey course in KAPL naval projects.
	Nuclear power plant engineering.	------	19	56 hours, combination of survey and fundamentals.
	Introduction to nuclear engineering.	------	60	32 hours, nuclear physics and reactor technology during working hours.
Other courses	Statistical analysis and design of experiments.	------	25	32-hour course at KAPL conducted by the general engineering laboratory.
	Shielding	------	1	30-day course at WAPD.
	Vibrations	------	1	6-day course at University of Michigan.
	Nuclear engineering	------	26	160-hour course for new employees; given by Union College.

3. Combustion Engineering-Superheater, Inc., Nuclear Engineering and Development Laboratory

The training program at Combustion Engineering is just beginning. The program will be divided into four major categories:

(*a*) *College training at B. S. and Ph. D. level.*—Courses at colleges in nuclear physics, heat transfer, hydraulics, etc. These are being conducted at New York University and Columbia University in New York and will be conducted at schools such as the Rensselaer Polytechnic Institute Extension School at Hartford. All costs are paid for by the company for selected students.

(*b*) *Formal training at Oak Ridge and at the Bettis plant.*—This includes the Oak Ridge School of Reactor Technology and the Bettis plant engineering, shielding, and core design courses. All costs are paid for by the company.

(*c*) *On-the-job training at other AEC laboratories.*—This involves placing Combustion personnel at other AEC laboratories (KAPL and BETTIS) for periods of 6 to 12 months. This is not formal schooling, but training is accomplished while actually working under the guidance of experienced scientists and engineers of the other AEC laboratories. As an example, 2 Combustion junior physicists have been working at the KAPL experimental physics facilities for 3 months. These individuals will conduct experiments on Combustion's own physics facilities when ready for operation. All costs are paid for by the company.

(*d*) *Training at Combustion Engineering.*—Selected engineers who have completed courses or schools listed in a, b, c, above will be used as lecturers at a 2 to 3 hour per week school which will be set up at Combustion Engineering. The purpose of this lecture series will be to diffuse the training received by these engineers to the maximum number of company employees. It is envi-

sioned that this lecture series could be eventually expanded into a complete nuclear training school similiar to the 23 week Bettis Plant Engineering Training School.

To aid in setting up this program, a professor from the University of Michigan has been hired as a consultant to recommend the details of the college training at the B. S. and Ph. D. levels. While in New York City, Combustion personnel have been taking night school and extension courses at Columbia University. Rensselaer Polytechnic Institute has an extension college at Hartford, Conn., and has indicated their willingness to set up any desired courses for Combustion's use after the move to the new laboratory site at Windsor, Conn. Other colleges are also available in the New England area. To carry out and administer the overall training program, a training director will be hired by Combustion. This will be a full-time position. Inquiries and interviews to fill this position have commenced.

Training schedule at combustion engineering

Name of course	School	Length (months)	Number taking	Number completed
Nuclear engineering	Columbia University	8	2	1
Do	Brooklyn Polytechnic Institute	8	2	
Do	City College of New York	8	1	
Do	Stevens Institute of Technology	8	1	
Do	New York University	8	1	
Reactor technology	Columbia University	8	1	
Reactor design	New York University	8	1	
Instrumentation and control	Brooklyn Polytechnic Institute	8	1	
Servomechanism	New York University	4		1
Heat transfer	do	8	3	
Advance heat transfer	City College of New York	4		1
Theory of elasticity	Stevens Institute of Technology	8	1	
Theory of plates and shells	do	8	1	
Problems in engineering	Columbia University	8		1
Stress analysis	Brooklyn Polytechnic Institute	8		1
Mechanical equipment	City College of New York	8	1	
Feed back amplifier design	New York University	8	1	
High-speed machines	City College of New York	8	1	
Physics	New York University	8	1	
Reactor physics	do	8	1	
Mathematical physics	Stevens	8		1
Anologue computers	New York University	4		1
Matrices	Stevens	8	1	
Numberical analysis	do	8		1
Advance mathematics for engineers	New York University	8		1
Advance fluid dynamics	do	8	1	
Differential equations	Columbia University	8	1	
Numerical solutions of engineering problems.	do	8	1	
Mathematical analysis	New York University	8	1	
Advanced algebra	do	8	1	
Operators in mathematics	Stevens	8		1
Digital computers	New York University	8	1	
Advanced mathematics	Columbia University	8	1	
Do	New York University	8	4	
Partial differential equations	Columbia University	8	1	
Plant engineering	Bettis	6	4	2
Shielding	do	2		1

NOTE.—4 months=1 college term; 8 months=2 college terms.

Training will be continued at least at this level after the move to the Windsor, Conn., laboratory. At the present time, approximately one-third of the scientific personnel are taking college level courses in night schools. All costs of these courses are paid for the company.

4. Duquesne Light Co. pressurized water reactor (PWR) program

(*a*) *Prior to participation in PWR program, 1953.*—

(i) About 20 management and supervisory personnel took an orientation course in reactor physics at Carnegie Institute of Technology. Course consisted of 12 lectures, 2 hours each.

(ii) One senior engineer was sent to Oak Ridge School of Reactor Technology.

(*b*) *Subsequent to Shippingport participation.*—

(i) A course of twenty 1½-hour lectures beginning in April and ending in September 1954 was given to above 40 top executives and engineers of Duquesne (including the president, vice president, chief engineer, and appropriate division heads) by Naval Reactors Branch and Westinghouse engineers. These lectures covered the fundamentals of reactor physics and engineering.

(ii) Commencing in April 1955, a total of some 120 Duquesne employees are receiving applied nuclear training. About 55 people will spend from 6 months to a year at the naval reactor test facility in Idaho, studying reactor theory and operation. These include chief engineer, recator engineers, maintenance engineers, test engineers, operating engineers, reactor operators, chemists, instrument and control engineers. The remainder of the plant crew will receive special instructions by the company appropriate to their job and will receive on-the-job training at the Shippingport, Pa., PWR site during the installation and test periods.

(iii) Eleven engineers were assigned to Bettis in June 1955, to work directly with Westinghouse in various phases of PWR design.

(iv) Twenty Duquesne engineers commenced a formal 120-hour course in reactor technology in January 1956 given by professors from the University of Pittsburgh and the Carnegie Institute of Technology. This course covers reactor physics, reactor engineering, dynamics and control, and health physics. It will be repeated for an additional 20 engineers. The course is paid for by Duquesne.

II. TRAINING

B. Training at shipyards

1. Summary

Each of the shipyards getting into the nuclear business faces a training problem. The requirement varies from general background information for management and supervisory personnel, through detailed technical education needed for designers, down to special training for draftsmen and various crafts. The yards meet this need with the help of the Naval Reactors Branch in many ways: First, personnel are sent for periods ranging from a few weeks to a year or more to other organizations for nuclear courses or for on-the-job training. These include the Oak Ridge School of Reactor Technology, on-the-job training at the Bettis plant or at other shipyards more advanced in nuclear work. Second, the yards encourage in various ways men to take courses at nearby universities. In many cases, special nuclear courses are arranged with the universities. Third, background lectures are given by personnel of the Naval Reactors Branch and by personnel of the shipyard who have completed some nuclear training. The Naval Reactors Branch lectures are generally 20 or more in number and are 1½ to 2 hours apiece. These are given by senior men in the organization and are accompanied by slides, charts, and models or actual pieces of equipment. Fourth, each of the yards has a need to train specific crafts in fabrication of stainless steel, lead, hydrogenous shielding materials, and other problems peculiar to nuclear power. In some cases special courses for draftsmen or apprentices have also been established.

The cost of this training at private shipyards is essentially all borne by the yard and is done largely after working hours. A summary of the courses follows.

Summary of training of shipyards personnel (completed or current)

[Men]

	Newport News	Bethlehem Steel	Mare Island	Portsmouth	Electric Boat
I. Off-station training:					
Bettis Reactor Engineering School (23 weeks)	6	2	13	12	2
Bettis Shielding School (6 weeks)	2	4	3	2	2
Bettis on-job training (1 year)	14				
Oak Ridge School of Reactor Technology (ORSORT) (1 year)	12	5	3	6	13
Bureau of Ships, Nuclear Propulsion Divisions (1 year)			2	3	
Electric Boat Division (1 year)			10	13	
Electric Boat Division (2–12 weeks)			14	142	
Universities (graduate work in nuclear engineering)	4				3
Other shipyards (approximately 1 year)		1	4		
Other off-station training	[1] 1	[2] 1			
II. Formal courses in nearby universities (man courses)	14	12	110	249	270
III. Background training in yard:					
Lectures by Naval Reactors Branch (30 to 40 hours)	200	200	150	[4] 80 / [5] 20	100
Other lectures (4 to 30 hours)			9	3	3
IV. Specific trade training in yard:					
Instruction in stainless steel and lead welding, shielding installation (6 to 8 weeks)			76	55	
Other			16		
Draftsmen, special course					83
V. Formal courses in yard (subcollege to postgraduate level) (man-courses)	223		265	488	2,278

[1] Argonne National Laboratory.
[2] Computer course at IBM.
[3] 2 series.

2. Newport News Shipbuilding & Dry Dock Co.

	Length of course	Number of men trained (completed or current)	Planned for 1956–57 (men)
I. Off-station courses:			
Oak Ridge School of Reactor Technology	1 year	12	3
Nuclear Science and Engineering, Argonne National Laboratory.	7 months	1	[6]
Reactor engineering, Bettis	6 months	6	4
Shielding, Bettis	do	2	2
On-the-job training:			
Shielding, Bettis	1 year	3	
Reactor plant engineering, Bettis	do	9	4
Metallurgy, Bettis	do	2	
II. Formal courses in nearby universities:			
Mathematics, University of Virginia	18 weeks	11	11
Atomic physics I and II, University of Virginia	16 weeks (each)	3	2
Summer Engineering School, North Carolina State.	8 weeks	4	4
III. Background training in yard: Lectures by Naval Reactors Branch in nuclear technology.		200	
IV. Formal courses in yard:			
Nuclear propulsion plant drafting, NNS&DDCo.	6 months	61	42
Shielding engineering, NNS&DDCo	16 weeks		8
Introduction to nuclear reactor engineering, NNS&DDCo.	13 weeks	42	
Nuclear reactor theory, NNS&DDCo	18 weeks	19	20
Atomic power lectures, NNS&DDCo	15 lectures	142	45

2. Newport News Shipbuilding & Dry Dock Co.—Continued

	1955	1956	1957
V. Technical training for personnel of USN, Supervisor of Shipbuilding, Newport News:			
By University of Virginia (extension courses):			
Mathematics	2	1	4
General physics laboratory	1	1	
Atomic physics		7	
Nuclear physics			7
Engineering drawing	1	1	
By Newport News Shipbuilding & Dry Dock Co.:			
Introduction to nuclear engineering	5		
Reactor theory		1	6
Reactor shielding			7

GENERAL COMMENTS.—(1) Student pays own way for University of Virginia courses. (2) Adult education courses are paid for by city of Newport News and shipyard. Student pays for texts. (6) Other courses are paid for by Newport News Shipbuilding & Dry Dock Co.

3. Bethlehem Steel Co., shipbuilding division

	Length of course	Men trained	Planned for 1956–57
I. Offstation full-time training for nuclear work:			
Oak Ridge School of Reactor Technology	1 year	5	2
Bettis Reactor School	23 weeks	2	2
Bettis Shielding School	6 weeks	4	
II. Courses in nearby universities:			
Preparatory to Oak Ridge		10	2
Preparatory to Bettis		4	2
Other graduate and undergraduate		12	20
III. Background training by shipyard for nuclear work: 23 2-hour lectures by Naval Reactors Branch personnel.		100	
IV. Specific trade training for nuclear work (planned for 1956):			
Qualification of welders	8 weeks		10
Shield installation	6 weeks		8
Primary plant installation	do		4
V. Formal courses in shipyard for nuclear work (planned for 1956):			
Introduction to nuclear engineering	13 weeks		20
Shielding engineering	do		12

4. Mare Island Naval Shipyard

	Length of course	Men
I. Off-station full-time training:		
Bettis Reactor engineering course	23 weeks	13
Oak Ridge School of Reactor Technology	1 year	3
Electric boat	do	10
Bureau of Ships (Nuclear Propulsion Division)	do	2
Electric boat—Shielding and foundation design	20 weeks	1
Field tests—Planned for late 1957	3 months	2
Job skill training for planners, July 1956	2 weeks	4
Inspection practices	do	1
Shield construction	1 month	1
Stainless steel welding, May 1956	6 weeks	2
Installation of reactor compartment and engine-room components, June 1956.	2 months	1
Cleanliness methods and procedures, July 1956	1 month	1
Control installation, September 1956	do	1
Portsmouth job skill training for planners, July 1956	2 weeks	4
II. Courses in nearby universities: Nuclear physics at Vallejo Junior College.	4 months	110
III. Background training by shipyard:		
Management and technical indoctrination (19 naval reactors branch lectures).	33 hours	150
Design indoctrination	11 hours	341
Trip to *Nautilus* prototype, Idaho	2 days	9
Introduction to nuclear engineering	24 hours	267
Water-cooled reactor plants	do	267
Health physics	4 hours	670
Introduction to nuclear engineering and water-cooled reactor plants for personnel in production department working on U. S. S. *Sargo*.	24 hours	200
Cleanliness	4 hours	200

4. Mare Island Naval Shipyard—Continued

	Length of course	Men
IV. Specific trade training (most of this commences in June 1956)	8 hours	27
U. S. S. *Sargo* radiation shielding	do	27
Radiation shielding design	20 hours	26
Nuclear propulsion plant foundation design	do	26
Quality control	10 hours	13
Reactor plant fluid systems design	16 hours	53
Nuclear propulsion plant control and instrumentation system	30 hours	28
Nuclear propulsion plant component design	16 hours	7
Radiation monitoring and reactor startup system	20 hours	28
Nuclear propulsion plant piping system design	24 hours	42
U. S. S. *Sargo* electrical plant and controls	8 hours	28
Nuclear power submarine electrical plant design	do	25
Special instructions and J. O. procedures for building nuclear-powered submarines.	do	46
Fabrication of stainless steel pipe	4 hours	200
Lead welding	6 weeks	26
Stainless steel welding	8 weeks	50
V. Formal courses in yard:		
Nuclear physics	3-4 months	69
Differential equations	do	16
College algebra, May 1956	4 months	60
Thermodynamics and heat transfer, August 1956	3 months	44
Strength of materials, August 1956	do	40–50
Servomechanisms and controls, August 1956	4 months	40
Calculus, January 1957	do	?
Thermodynamics, January 1957	do	?

5. Portsmouth Naval Shipyard, Portsmouth, N. H.

	Length of course	Men
I. Off-station full-time training:		
Bettis Reactor School	23 weeks	12
Bettis Shielding School	6 weeks	2
Oak Ridge School of Reactor Technology	1 year	6
Electric boat	do	13
Superintendent of Shipbuilding, Groton, Conn.:		
Technical, engineering	3–4 months	75
Planning department	6–7 months	67
Bureau of Ships, nuclear propulsion divisions	1 year	3
II. Courses at nearby universities: 5 semesters of university courses, run by University of New Hampshire and MIT summer sessions		[1] 249
III. Background training by shipyard:		
Technical lecture series (20 lectures by naval reactors branch)	35 hours	50
Second naval reactors branch lecture series (25 lectures)	40 hours	90
Supervisory and technical indoctrination	33 hours	667
Design technical conference (more details on above)	100 hours / 5½ months	25–30
Technical lectures on U. S. S. *Nautilus*	8 hours	57
IV. Specific trade training:		
Installation of shielding	6–8 weeks	25
Welding, consumable insert procedure, starts on Apr. 16 (most of training will be conducted from June to December 1956. This will comprise about one-seventh of training to date).	8 weeks	30
V. Formal courses in yard, subcollege to postgraduate level since January 1955.		[1] 488

[1] Man-courses.

6. Electric Boat Division, General Dynamics Corp.

	Duration	Man-courses
I. Off-station full-time training:		
Bettis:		
Reactor Engineering School	23 weeks	2
Shielding School	6 weeks	2
Oak Ridge School of Reactor Technology	1 year	15
MIT fellowships	do	3
II. Courses in nearby universities:		
Engineers	1 term	[1] 243
MIT summer, engineers	2 weeks	[2] 71
III. Background training by shipyard:		
For supervisors and key craftsmen:		
U. S. S. *Nautilus* prototype	50 hours	25
U. S. S. *Nautilus*	do	216
U. S. S. *Seawolf*	35 hours	170
Technical lectures for management and engineers (by NRB)	do	100
IV. Specific trade training: Draftsmen special courses (now expanding)	25 hours	[2] 127
V. Formal courses in yard:		
Math review including differential equations	6 to 8 months	95
Nuclear engineering	35 hours	172
Elementary nuclear physics	15 hours	473
Basic nuclear submarine design	20 hours	103
General lecture series on reactor plant systems	45 hours	335
Symposium on nuclear submarine design	2 hours	1, 100

[1] Approximately 90 percent of men studying subjects related to nuclear propulsion.
[2] Approximately 65 percent of men studying subjects related to nuclear propulsion.

7. Training naval shipyard engineers with Bureau of Ships

Two employees from the Mare Island Naval Shipyard and 3 employees from the Portsmouth Naval Shipyard were selected early in 1955 for 1 year of on-the-job training with the Bureau of Ships Nuclear Propulsion Division; 4 of these employees are staying for an additional 6 months of training.

Early in 1956 the following additional action was taken on selecting shipyard employees for such training:

Shipyard	Number interviewed	Number selected	Period of training
New York	5	3	18 months.
Philadelphia	8	0	
Puget Sound	4	2	Do.
San Francisco	4	2	Do.

C. Training of Naval Reactors Branch (AEC) personnel

Personnel of the Naval Reactors Branch receive education in nuclear engineering in four ways:

First, a basic background is usually given at either the Oak Ridge School of Reactor Technology or the 15-month advanced nuclear engineering course at the Massachusetts Institute of Technology; 34 engineers and scientists have completed the Oak Ridge School of Reactor Technology course under Naval Reactors Branch sponsorship (not counting those under sponsorship by the Bureau of Ships, shipyards, or contractors); 29 naval officers have completed the MIT course, starting May 1956, approximately 6 Naval Reactors Branch engineers per course will take the Bettis 23-week reactor engineering course.

Second, several series of technical lectures are given by senior Naval Reactors Branch engineers or occasionally by outside scientists or engineers. A list of these lectures is given in table I below.

Third, arrangements are made for field trips to the *Nautilus*, to shipyards or on board visiting ships nearby (i. e. at the Naval Gun Factory, Annapolis, Baltimore, Norfolk, or Newport News). Weekend visits are also arranged to other field activities of the program.

Fourth, arrangements are made with Maryland, George Washington, Georgetown, and American Universities for extra courses; some of these are taught in the Navy Building immediately after work, others are on campus at night. Some are special courses which do not give college credit. A recent poll of Naval

Reactors Branch personnel indicated 24 men had taken 1 or more of these courses since coming to the Naval Reactors Branch; some men have completed as many as 6.

As new organizations come into the naval reactors program, senior NRB personnel give background and technical lectures both to top company officials and to engineering personnel. A list of these lecture series is given in Table II of this section.

TABLE I.—*Lectures for Naval Reactors Branch personnel*

Starting date	Subject	Number of lectures	Hours per lecture	Number of persons attending
June 1951	General nuclear physics by Dr. S. Goudsmit for junior personnel of NRB.	11	2½	10
Aug. 30, 1951	Principles of reactor design	8	1	20
Nov. 6, 1951	Background lectures for nonengineers for 5 months twice a week.	45	1	15
July 7–28, 1952	Reactor engineering systems, mathematics and components.	12	1	20
Apr. 5 to May 3, 1954	Naval architecture	5	1	30
Apr. 8 to May 27, 1954	Marine engineering	8	1	29
Sept. 7 to Nov. 9, 1954	Nuclear and general physics	20	1	5
May 26 to Aug. 29, 1955	Classified technical survey	14	1	5
May 31 to Aug. 31, 1955	Unclassified orientations	16	1	7
July to Sept. 1955	Nuclear physics	10	1	5–15
Do	Systems and components	14	1	5–15
	Reactor design, control and shielding.	13	1	5–15
Do	Reactor theory	12	1	5–15
Sept. 15, 1955 to Jan. 10, 1956	Overall scope of the program (2 times a week).	33	1	11
1952 to present	Information meetings (1 hour per week). This series is intended to keep technical personnel up to date on progress in other parts of the naval reactors programs than their own.	Continuing	1	[1] 50
Mar. 6 to May 31, 1956	Elementary reactor theory	24	1	10

[1] Average.

TABLE II.—*Lectures by Naval Reactors Branch to other organizations*

[1½ to 2 hours each]

Date	Number of lectures	Subject	Number of students	Organization
1948	28	Nuclear propulsion	100	Bureau of Ships.
1948–49	20	do	50	Babcock & Wilcox Co.[1]
1949	20	do	80	Bureau of Ships.
1949	20	do	100	Allis Chalmers Co.[1]
1949	20	Background for top executives.	50	Westinghouse Electric Co.[1]
1949	20	Nuclear propulsion for engineers.	50	Do.
1949	6	Nuclear propulsion	100	U. S. Naval Academy.
1950	4	do	1,000	All submarine bases (New London, Norfolk, Key West, San Diego, and Pearl Harbor).
1950	20	do	50	Portsmouth Shipyard.
1950	20	do	100	Electric Boat Co.[1]
1950–51	11	Reactor control	17	Bureau of Ships.
1953	12	Nuclear propulsion	200	Newport News Shipbuilding and Drydock Co.[1]
1953	6	Reactor shielding	20	Bureau of Ships.
1954	6	Nuclear propulsion	40	Do.
1954	6	Reactor shielding	20	Do.
1954–55	20	Nuclear propulsion	40	Duquesne Light Co.[1]
1955	10	do	150	Mare Island Shipyard.
1955	23	do	200	Bethlehem Steel Co.[1]
1955	23	do	90	Portsmouth Shipyard.
1956	10	do	120	Bureau of Ships.

[1] President, vice president and other top officials of company included.

D. Basic nuclear engineering education program

1. *Naval nuclear engineering courses at Massachusetts Institute of Technology*

(*a*) ***The 15-month course.***—Immediately after World War II nearly all information on reactor technology was classified and was to be found only at the AEC's national laboratories at Oak Ridge, Tenn., and Chicago, Ill. In the spring of 1949 at the request of Adm. (then Capt.) H. G. Rickover, the Massachusetts Institute of Technology agreed to initiate a special curriculum in nuclear engineering for selected naval officer students. These students had previously received a Massachusetts Institute of Technology degree in Naval Architecture and Marine Engineering, and then after some field experience, were sent back to the institute for the nuclear course. At that time (1949) the institute did not offer a regular curriculum in nuclear engineering, so this special Navy group took courses, mostly in the physics department, leading to the degree of master of science in physics. This arrangement was carried out for 2 officers in the 1949–50 academic year, 4 officers in 1950–51, and 4 officers in 1951–52, with minor modifications in curriculum each year.

In the fall of 1951 Admiral Rickover asked the Massachusetts Institute of Technology to investigate the possibilities of future modifications to this curriculum aimed entirely at establishing the curriculum as an engineering one rather than as a science curriculum. The institute took the position that it had become clear to them, partly through the requests of Admiral Rickover and partly through their experiences at the Brookhaven and Oak Ridge National Laboratories that the time was ripe for the establishment of nuclear engineering as a separate engineering field of its own. The institute, therefore, established in 1952 a regular nuclear engineering curriculum under the guidance of Dr. Manson Benedict. The source of naval students for this course was expanded to include officers with previous postgraduate training in mechanical and electrical engineering as well as marine engineering.

The advanced nuclear engineering course for engineering duty naval officers is normally fifteen months long and leads to the degree of master of science in nuclear engineering. Four engineering duty officers were assigned to this course in 1952–53, 4 in 1953–54, 5 in 1954–55, and 6 are currently enrolled. Thus a total of 29 officers have this far been sent to the Massachusetts Institute of Technology for advanced training in nuclear engineering.

The curriculum for this course for 1955 follows:

MIT advanced nuclear engineering course

[15 months; leads to M. S. in nuclear engineering]

MIT course No.	Subject	Hours per week		
		Recitation	Laboratory	Preparation
	TERM 1—SUMMER			
8.06N	Nuclear physics. Depending on men's prior training, additional subjects to be selected from—			
M351	Advanced calculus for engineers	3	0	6
10.31	Chemical engineering	4	0	6
M352	Advanced calculus	4	0	5
10.32	Chemical engineering	4	0	6
8.051	Atomic and nuclear physics	4	0	5
	TERM 2—FALL			
8.511	Nuclear physics I	3	0	6
3.306	Technology of nuclear reactor mathematics	3	0	6
2.521	Heat transfer, advance	3	0	6
N21	Nuclear reactor theory I	3	0	9
N20	Biological effects of radiation	3	0	6
	Total hours, 50.			
	TERM 3—SPRING			
8.512	Nuclear physics II	3	0	6
8.512	Nuclear physics laboratory	1	3	3
N23	Nuclear reactor engineering	3	0	9
	Thesis		10	
	One elective selected from—			
N22	Nuclear reactor theory II	3	0	9
2.522	Advanced heat transfer II			
2.783	Contraction problems in M. E			
	Total hours, 50.			
	TERM 4—SUMMER 1ST HALF			
	Thesis		20	

(*b*) *The 3-year course.*—In 1954 a nuclear engineering specialty was added to the 4 already existing specialties in the 3 year naval construction and engineering course at the Massachusetts Institute of Technology. Officers selected for this course need have no previous postgraduate training. The purpose of this specialty is the same as that of the advanced nuclear engineering course; that is, to train engineering personnel for design, development, construction, and maintenance billets in the naval nuclear propulsion field. The curriculum of the nuclear specialty of the three year course is a combination of the nuclear engineering subjects of the advanced nuclear engineering course (15 months) and the naval architecture and marine engineering subjects common to all 5 specialties. Graduates of the naval construction and engineering course receive the degree of naval engineer. There are 4 officers currently enrolled in the nuclear specialty who entered the Institute in the summer of 1954 and 4 who entered in 1955. The curriculum for this course follows:

MIT 3-year course for naval construction and engineering (nuclear)

MIT course No.	Subject	Hours per week		
		Recitation	Laboratory	Preparation
	FIRST SUMMER			
	Math and physics review.			
	TERM I			
1.612	Fluid mechanics	3	0	6
2.081	Stress of materials	3	0	6
2.402	Heat engineering	4	0	8
8.051	Atomic and nuclear physics	4	0	5
13.17	History of warships	3	0	4
M351	Advance calculus for engineers	3	0	6
	Total hours, 55.			
	TERM II			
*2.422	Heat engineering	2	1	4
10.311	Heat transfer	3	0	3
13.012	Naval architecture	4	1	7
13.12	Warship general arrangements	3	0	3
13.21	Warship form design	0	5	0
13.791	Marine propellers	3	0	6
M352	Advance calculus for engineers	3	0	6
	Total hours, 56.			
	TERM III			
3.391	Properties of metals	2	1	3
*8.511	Nuclear physics I	3	0	6
13.13	Warship structure theory I	3	0	6
13.22	Warship general design	0	5	0
13.75	Warship properties I	3	2	6
13.90	Warship electrical engineering	3	0	4
15.11	Industrial management Int	3	0	6
	Total hours, 56.			
	TERM IV			
3.392	Properties of metals	2	1	3
*3.44	Behavior of metals at elevated temperatures	2	0	4
*8.512	Nuclear physics II	3	0	6
*8.513	Nuclear physics laboratory	1	3	3
13.241	Warship structural design I-A	0	3	0
13.76	Warship properties II	2	4	4
*N20	Biological effects of nuclear radiation	3	0	6
	Total hours, 50.			
	TERM V			
3.396	Technology of nuclear reactor material	3	0	6
13.15	Warship basic design I	3	2	6
13.16	Warship basic design II	3	0	6
*16.30	Automatic control principles	3	0	9
*N21	Nuclear reactor theory I	3	0	9
T	Thesis	0	3	0
	Total hours, 56.			
	TERM VI			
*13.04	Advance ship design	2	0	8
13.26	Preliminary design of warships	0	9	0
13.54	Mr. engineering dynamics	2	0	4
*N23	Nuclear reactor engineering	3	0	9
T	Thesis	0	17	0
	Total hours, 54.			

*Subjects are those peculiar to the specialty.

2. *Oak Ridge School of Reactor Technology (ORSORT)*

In 1949 Admiral (then Captain) H. G. Rickover arranged with the Atomic Energy Commission to establish the Oak Ridge School of Reactor Technology to give a 1-year formal classified program in nuclear science and engineering, including laboratory work. The first pilot class started in early 1950 with about 20 students. Attendance has increased steadily to the present level of 120 students. Close liaison has been maintained with the school by the Naval Reactors Branch, since Admiral Rickover has been on the school board since its inception. Thirty-four scientists and engineers have completed the course under the sponsorship of the Naval Reactors Branch and another 22 from the Bureau of Ships and its naval shipyards. Another approximately 60 engineers have been sent from the naval and reactors contractors.

Each year the students from the Naval Reactors Branch completing the Oak Ridge course are asked to write up their thoughts on how the school could be improved and these suggestions are incorporated where appropriate into the next year's program. Topics for the summer theses are suggested by Naval Reactors Branch personnel and the development of these projects is followed by Naval Reactors Branch personnel in Washington.

Recently by special arrangement technical military personnel in the Naval Reactors Branch have been allowed to attend the course on a 6-month basis, omitting the summer project to go directly to work in the naval reactors program.

3. *Operator's Training*

Training naval personnel to operate and maintain a nuclear powerplant at sea is another major educational task. In February 1951, a group of 2 officers and 10 enlisted men scheduled to become the nucleus of the *Nautilus* engineer crew commenced a 10-month training course at the Bettis plant in Pittsburgh.

Although the personnel were of widely varying backgrounds, it was the objective of the course to turn out men who understood principles not merely detailed operating instructions. Engineering courses were therefore on a par with comparable college offerings. Instruction was given by Westinghouse personnel and, by special arrangement, by members of the faculty of the University of Pittsburgh. Additional groups were subsequently trained to make up the entire *Nautilus* engineer group.

This training course was later moved to the *Nautilus* prototype site at Idaho and finally to the submarine base at New London, Conn., where it is still taught along the lines of the original Bettis course. The curriculum is attached to the original copies of this testimony as appendix 1.

A similar program was established at the *Seawolf* prototype at Schenectady, N. Y. This program was also later integrated into the New London school.

To date the naval training program has graduated a total of 237 officers and men who have not only received training in the details of one reactor but also a college level introduction to the principles of nuclear reactors and their control. This represents a significant pool of power reactor experience and background.

It is interesting to note that when the Navy this spring advanced 200 of its 600,000 enlisted men to officer rank, 17 of them were from the 215 graduates of the naval nuclear power training course. Since its inception, 34 enlisted graduates of the naval nuclear course have been made officers. (An outline of the qualification procedure for chief operator is appended to this document as an indication of the extent of this operational training.)

4. *Training for medical officers and hospitalmen*

(*a*) *Medical officers.*—Naval Medical Corps officers have been trained for the nuclear power program by adapting a course developed originally for the Armed Forces special weapons program. This course includes the following:

	Weeks
Special radiobiology course, Reed College, Portland, Oreg	24
Field training at AEC Hanford Works	6
Course at Nevada atomic weapons test site	4
Course at Sandia Base, Nev	1
Training at Walter Reed Laboratory, Washington, D. C	6

The men then report to a nuclear submarine prototype for training, then to a ship for duty. All have medical degrees and those who will report to submarines are graduates of the Navy submarine school at New London, Conn.

This program is now being revised to fit more closely the needs of the nuclear propulsion program (as distinct from radiological defense). The revised curriculum is being planned (tentatively) for the University of Rochester and will incorporate in 8½ months or less all of the courses in the above table. The outline for the curriculum is attached as an appendix to this document. The training at the prototypes and on shipboard will be continued.

(*b*) *Hospitalmen.*—Hospitalmen are enlisted men who perform minor medical functions aboard ship. The official requirements for the hospitalman billet for nuclear vessels is attached as an appendix to this document. Their training for nuclear propulsion has been as follows:

	Months
Radioisotope school at the Naval Medical Research Institute, Bethesda, Md.	8
Nuclear power school, New London Submarine Base, Conn.	6
Onsite training, nuclear submarine prototype plant	6

This is in addition to the special training received by all hospitalmen qualified for submarine duty.

The program is now being modified to fit more specifically the needs of the nuclear power program. The course now consists of:

	Months
Nuclear power school, New London, less 200 hours of nonpertinent specialties	4
Special training at New London Submarine Base in radiological principles and techniques	4
Operational training aboard nuclear vessel	2–4

E. Miscellaneous training

1. Reactor design and technology manuals

The technology developed for the U. S. S *Nautilus* and U. S. S. *Seawolf* power plants was contained mainly in internal documents and in technical conference reports. To prevent this information from being lost as new projects were begun under new personnel, a series of handbooks is being prepared on each of several fields of reactor technology in which the contributions of the naval reactors program have been dominant. Five of these have been published to date, and an additional seven are currently in preparation. More fields will be covered as information develops. The fields covered to date are:

Liquid Metals Handbook. First edition, edited by R. N. Lyon, June 1950; second edition, edited by R. N. Lyon, June 1952; third edition (Sodium-NaK Supplement), edited by C. B. Jackson, first printing, June 1955; second printing (revised), November 1955.

Metallurgy of Zirconium. Edited by B. Lustman and F. Kerze, Jr., July 1955.

The Metal Beryllium. Edited by D. W. White and J. E. Burke, July 1955.

Bibliography of Reactor Computer Codes, Report AECU–3078. Edited by R. S. Brodsky, December 1955.

Reactor Shielding Design Manual. Edited by T. Rockwell III, March 1955.

Currently in preparation are:

Corrosion and Wear Handbook for Water-cooled Reactors. Edited by D. J. De Paul.

Naval Reactor Physics Design Manual. Edited by A. Radowsky.

Reactor Core Design Manual. Edited by N. J. Palladino.

Reactor Plant Piping Handbook. Edited by M. Shaw.

Reactor Heat Transfer Handbook. Edited by J. Zerbe.

Medical and Radiological Aspects of Naval Nuclear Propulsion Plants. Edited by J. H. Ebersole, Lieutenant (MC) USN.

Hafnium Handbook.

Each of these books contains several hundred pages of basic data, empirical correlations, design and calculational procedures, and equipment and instrumentation information. These books will be revised periodically to keep them current, and together they will cover most of the basic technology of power reactors. They are written in a practical manner by the persons who actually developed the information originally, and in cases where discrepancies exist between various data on procedures, these discrepancies are discussed and evaluated in practical terms by persons with first-hand knowledge of the informa-

tion and its application. Attached as appendixes to this document are tables of contents of the first of these handbooks, which indicate the scope and detail of the material covered.

2. Instruction books for naval nuclear powerplants

Comprehensive and detailed instruction books for all naval nuclear powerplants and for the pressurized water reactor were considered to be necessary as a means for training operating personnel in the field of nuclear powerplant operation and maintenance. Each new plant (including prototypes) requires an entirely new set of instruction books. These books contain specially made exploded or cutaway drawings and photographs and a great many flow diagrams, charts, wiring, drawings, etc.

Since each set of books represents many thousands of man-hours of effort, several attempts were made by the Naval Reactors Branch to minimize the time of senior scientific and engineering personnel required in their preparation. The books were contracted to two different professional technical writing firms in succession, but neither of these companies was able to produce a satisfactory book, even with very close followup. Efforts to utilize mostly junior engineers in the preparation of these books also proved unsuccessful. In the end it was apparent that, in order to insure a satisfactory job, a great deal of time was required of senior engineers, both in the contractors' organizations and in the Naval Reactors Branch.

The books for the *Nautilus* and *Seawolf* cost approximately $200,000 total. Each of these books was incorporated into 6 volumes totaling 35 chapters containing approximately 1,400 pages. Two hundred sets of these books have been distributed to shipyards, submarine tenders, technical desks, and other appropriate personnel throughout the Navy. The preparation of these books in itself fulfilled a major training function; their existence forms a basis for design of future plants and provides raw material for training of new personnel.

3. Training by participation in disassembly of radioactive Canadian and Oak Ridge reactors

On December 12, 1952, an accident damaged the NRX reactor at Chalk River, Ontario, and spread large quantities of radioactivity throughout the reactor structure and building. This required complete disassembly and decontamination of the reactor, decontamination of the reactor building, and reassembly of new components into the system.

The Naval Reactors Branch utilized this situation to provide training for personnel in actual reactor decontamination and repair. A total of 214 persons from the Naval Reactor Program expended 1,300 man-days of labor and absorbed about 500 roentgens of radiation among them. As a part of this effort, United States decontamination equipment, radiation detection instrumentation, and personnel protection equipment were shipped to Chalk River.

The operation was a complicated one, requiring considerable on-the-spot planning and work with wooden mockups outside of the radioactively contaminated zone. Procedures for accomplishing this were developed as the job progressed, and equipment and techniques were evaluated.

Some time later, when the Homogeneous Reactor Experiment (HRE) at Oak Ridge was disassembled, several men from the Naval Reactors Program were sent to Oak Ridge for a similar purpose. As a result of this training, over 200 men in the Naval Reactors Program have now obtained first-hand experience working with highly radioactive piping and components, doing repair work under highly adverse radiological conditions. This experience cannot be simulated by artificial means, and the training value of this work is considered high.

4. Training in statistics and design of experiments

Design and operation of nuclear powerplants require a higher level of training and competence than does most engineering. To help obtain a high level of engineering in all of the naval nuclear development work, courses have been instigated at the Bettis plant and at the Knolls Atomic Power Laboratory (KAPL) in statistical design and analysis of experiments. It is planned to establish such courses at the Combustion Engineering Nuclear Engineering Laboratory and perhaps at the shipyards as well. Education of nuclear engineers in this field is considered to be essential to the rapid development of nuclear power.

Full-time senior statisticians have been hired at Bettis and at KAPL for this purpose and courses are soon to be given at both places to all engineers and scientists. The Naval Reactors Branch has taken the initiative in establishing these programs and has made available the services of a senior statistician in the Bureau of Ships to analyze experimental programs and to help evolve programs of maximum effectiveness.

It is intended to apply the science of statistically designing experiments to all appropriate parts of the naval nuclear program as soon as personnel become trained in its use.

III. RECRUITING TECHNICAL PERSONNEL

Once it is recognized that one cannot recruit experienced nuclear power engineers, the method of obtaining technical personnel changes. The naval program has not attempted to obtain reactor people from other nuclear projects but instead has tried to hire persons of sound technical background and potential for development and has assumed the burden of training them as described above.

In the Naval Reactors Branch itself, civilian employees are recruited directly from colleges. Applicants are screened at universities or written applications are reviewed in Washington. Those applicants who appear promising are asked to come to Washington at their own expense for Saturday interviews. Each man is interviewed by 3 to 5 top technical personnel for 30 minutes to an hour each, and then by Admiral Rickover. During the past 6 months, 37 civilian applications were reviewed, 26 of these individuals were interviewed in Washington, and 6 were selected for employment. These statistics are typical of the last 2 or 3 years.

A similar story of selection and training exists for naval officers, but is not considered pertinent to this report.

IV. MAXIMUM UTILIZATION OF OTHER SKILLS

The training discussed above will be continued and expanded until all of the technical and semitechnical personnel working in the naval reactors program have been given an appropriately detailed competence in nuclear power engineering. This training, as has been noted, extends to draftsmen and technicians as well as to professional people. The training is intended to develop in engineers a detailed competence in the basic sciences of physics, chemistry, metallurgy, and mathematics. The scientists in the program are in turn given basic understanding of the engineering problems involved in the plant.

However, in spite of this program to create through training a large number of nuclear specialists, it is essential that existing skills be utilized to a maximum extent, particularly while the number of persons highly trained in the details of nuclear engineering and physics are so few. There are four areas in which this is being done in the naval program:

(*a*) There is a continual effort to build up outside, nonnuclear organizations to handle more and more parts of the program, so that these tasks need not be done by the AEC laboratories. Development, manufacturing, and testing of special reactor-plant components such as pumps, heat exchangers, valves, and reactor control mechanisms have now been turned almost entirely over to outside firms. In addition, construction of considerable highly specialized equipment and prosecution of many development projects have been subcontracted. Even the nuclear reactor cores themselves will soon be manufactured by industrial concerns outside of the AEC laboratories. This has been made possible by intensive specialized training of these organizations by senior personnel of the Naval Reactors Branch and its reactor contractors.

(*b*) Because of the acute shortage of nuclear physicists, special efforts have been made to train engineers to take over more activities normally handled by physicists. These include design, construction, and operation of nuclear mockups ("critical experiments"); interpretation of experimental and theoretical data from the physics groups, and application of this information to reactor design. In most cases a great deal of specialized training is required to equip engineers to do these jobs well, but it has been found that freeing the physicists from these essentially engineering aspects of nuclear-reactor design allows the physicists more time to do work for which their special education and aptitude equips them, and the resultant application of engineering to the nuclear physics domain has been highly beneficial.

(*c*) Experienced engineers with no nuclear background can be trained with only a small amount of specially aimed nuclear training to do a competent job of engineering design and computation on many aspects of reactors and their associated equipment and systems. As in the previous case, the use of such men, experienced in other fields of engineering, is often more successful than the exclusive use of young engineers experienced only by brief exposure to nuclear engineering.

(*d*) In many fields work is normally done by nuclear scientists or engineers which can be done as well or better by trained technicians. This includes operation of some experimental equipment, including critical facilities; many aspects of preparation and running problems through large-scale digital computing machines; and other phases of the experimental program. Intelligent training courses specifically devised for preparing technicians for these jobs have freed an appreciable number of nuclear scientists and engineers for work which demands the professional background.

Each of these problems has been the subject of several meetings between the Naval Reactors Branch and company management, and specific steps were taken locally along the lines indicated above. In some cases, scientists were dubious that these changes could be successful, and they were then made experimentally in particular test cases. These have nearly all been highly successful and further moves in this direction are planned.

APPENDIXES

APPENDIX 1

UNITED STATES NAVAL SUBMARINE SCHOOL, NEW LONDON, CONN.—NUCLEAR POWER TRAINING PROGRAM CURRICULUMS, BASIC AND ADVANCED COURSES

NUCLEAR POWER SCHOOL

Mission.—The mission of the Nuclear Power School is to provide a permanent fully equipped institution for the training of naval personnel, officer and enlisted, in the field of nuclear power in order that these personnel may be qualified to serve in the Navy's nuclear engineering departments.

Objectives.—The objectives of the Nuclear Power School in carrying out the above mission are:

1. To provide the student with a broad academic background in subjects related to the nuclear field in order that he may fully develop his nuclear learning.
2. To provide the student with a sound theoretical knowledge and an understanding of the principles of nuclear physics and reactor engineering.
3. To provide the student with a knowledge of nuclear powerplant construction, instrumentation, design operation, and mechanical and electrical components.
4. To provide the student with instruction on the application of his nuclear knowledge to the safe, intelligent operation of a nuclear plant in accordance with sound engineering practices and in accordance with governing directives.
5. To provide the student with the background for intelligent communication with technical and scientific personnel and for intelligent use of applicable technical and scientific papers and works.
6. To provide the student with the scientific skepticism essential for an analytical approach to engineering.

Courses.—To accomplish the above mission and in implementation of the objectives, the Nuclear Power will conduct the following courses:

1. Basic nuclear power course—for enlisted personnel.
2. Advanced nuclear power course—for officers, and such enlisted personnel as may be especially qualified.

Convening dates.—Both courses will convene simultaneously and normally will convene twice yearly, in January and July.

Enlisted students.—It is considered that for enlisted personnel to properly assimilate the basic nuclear power course, they should have at least the following background of previous training:

1. Be a high-school graduate, or have completed equivalent education.
2. Be a class A school graduate, engineering type course, or have equivalent engineering experience as evidenced by petty officer rating.

Officer students.—It is considered that for officers or other personnel to be suited for the advanced nuclear power course, they should have at least the following background of previous training:

1. Be a college graduate with an engineering degree, or have completed equivalent education.
2. Be experienced in practical naval engineering.

Notes on curriculum.—1. While certain areas of instruction are common to both courses, for practical reasons and to insure the best possible training, the basic course and the advanced course are administered as two separate curricula.

2. Fundamentally, each course is 21 weeks long and consists of 630 classroom and laboratory hours. Each course is administered during a 5-day week with 7-hour days, including 1 hour assigned for study each day. Grand total of classroom, laboratory, and study hours during each course is 735 hours.

3. In addition, approximately 20 to 30 hours of further outside study will be required by each student per week.

4. The basic course will terminate at 17 weeks for certain enlisted students in order that they may depart for special steel-welding training.

5. Generally, each course will be followed by a 17-week course at a land-based prototype nuclear powerplant for operational training.

Special note.—Student official orders to and from nuclear power school courses will be permanent change of duty orders.

Examinations.—Appropriate examinations and tests, with resultant remarks on fitness and performance, will be administered throughout courses.

Texts and references.—1. An adequate supply of texts required for each course will be maintained by the Nuclear Power School and they will be loaned to the student during the period of his course.

2. A suitable reference library will be maintained by the Nuclear Power School for the use of staff and students.

3. The bibliography for each course is as listed in the accompanying curricula summaries.

Training aids.—1. Pertinent training aids will be maintained on hand and will be used in accordance with NavPers 12500.

2. Transparencies, in particular, will be used throughout plant-information instruction.

References.—1. All principal references are listed in the accompanying curricula summaries. Less significant references are not listed.

2. All pertinent and applicable manufacturers' instruction books are used with the plant-information parts of the curricula.

BASIC NUCLEAR POWER COURSE CURRICULUM

A. Academic section

1. Basic mathematics (55 hours)

(*a*) *Topics.*—Arithmetic of fractions and decimals, algebraic addition and subtraction, laws of exponents, multiplication and division of polynomials, factoring, addition and multiplication of rational functions, equations, graphs, simultaneous and quadratic equations, permutations and combinations, the binomial theorem, series, roots and powers, logarithms, selected theorems from plane and solid geometry, angles, radians, quadrants, definition of trigonometric functions, the unit circle, graphs of trigonometric functions, basic trigonometric identities, trigonometric reduction formulae, use of natural trigonometric tables, use of logarithmic trigonometric tables, functions, limits, continuity, definition of the derivative, the definite integral, applications.

(*b*) *Texts.*—Practical Mathematics, volumes I and II—Edited by Kimball; Basic Mathematics Workbook—Keller and Zant; Mathematical Tables From the Handbook of Chemistry and Physics.

(*c*) *References.*—Outline Series, Trigonometry—Schaum; Elements of Algebra—Peck; A First Year of College Mathematics—Brink; Plane Trigonometry—Dadourian; Brief College Algebra—Hart; Elementary Concepts of Mathematics—Jones.

2. Modern Physics (90 hours)

(*a*) *Topics.*—Vector quantities, accelerated motion, Newton's laws, work, energy and power, momentum, pressure temperature and gas laws, kinetic theory, electric fields and potentials, electric currents, moving particles in magnetic fields, thermionic emission, light and spectra, special theory of relativity, quanta,

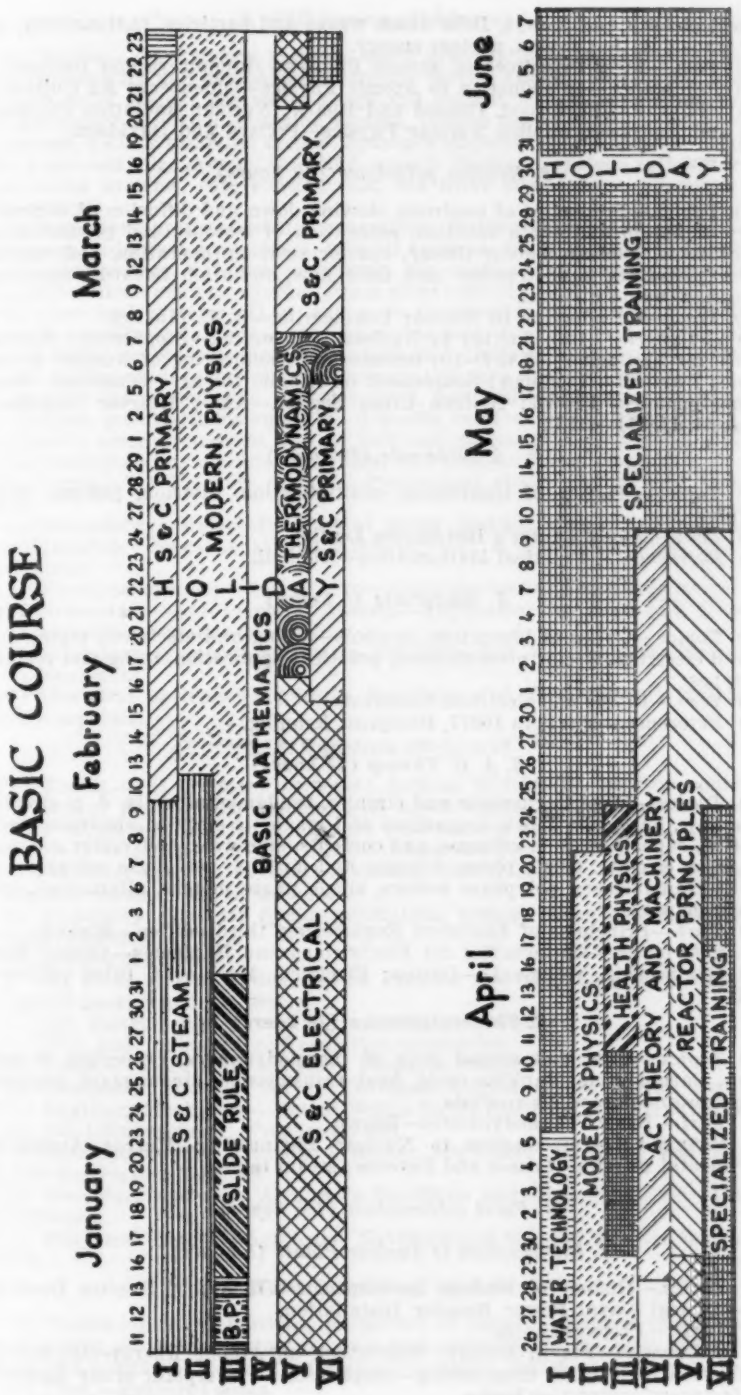

BASIC COURSE
January
February
March
April
May
June
S & C STEAM
B.P.
SLIDE RULE
H S&C PRIMARY
O MODERN PHYSICS
L
I
D
BASIC MATHEMATICS
(A) THERMODYNAMICS
Y S&C PRIMARY
S&C ELECTRICAL
S&C PRIMARY
WATER TECHNOLOGY
MODERN PHYSICS
HEALTH PHYSICS
AC THEORY AND MACHINERY
REACTOR PRINCIPLES
SPECIALIZED TRAINING
SPECIALIZED TRAINING
H O L I D A Y
I
II
III
IV
V
VI

photo-electricity and X-rays, Bohr atom, waves and particles, radioactivity, nuclear transmutation, fission, nuclear energy.

(*b*) *Text.*—First Principles of Atomic Physics—Humphreys and Beringer.

(*c*) *References.*—Introduction to Atomic Physics—Oldenberg; An Outline of Atomic Physics—Blackwood, Osgood and Ruark; Nuclear Radiation Physics—Lapp and Andrews; Applied Nuclear Physics—Pollard and Davidson.

3. Reactor principles (40 hours)

(*a*) *Topics.*—Properties of neutrons, slowing down and diffusion of neutrons, theory of fission and chain reaction, separation of isotopes and production of reactor fuels, nuclear reactor theory, reactor start-up, operation, and control, reactor materials, heat transfer and fluid flow, radiation hazards, shielding, monitoring, waste disposal.

(*b*) *Text.*—Introduction to Nuclear Engineering—R. L. Murray.

(*c*) *References.*—Introduction to Nuclear Engineering—Stephenson; Nuclear Physics for Engineers—WAPD-10; Science and Engineering of Nuclear Power, volumes I and II—Goodman; Sourcebook on Atomic Energy—Glasstone; Basic Thermodynamics—Brown; Neltron Cross Section—AEC; Reactor Handbook, volumes I, II, III—AEC.

4. Slide rule (10 hours)

(*a*) *Topics.*—Theory of logarithms—multiplication, division, powers, roots, trig functions.

(*b*) *Text.*—Manufacturer's Instruction Leaflet.

(*c*) *References.*—Practical Mathematics—Kimball.

5. Blueprints (5 hours)

(*a*) *Topics.*—Types of blueprints, symbols—piping and electrical, piping system and electrical circuit presentations, practical application, using and reading both types.

(*b*) *Text.*—Piping and electrical blueprints.

(*c*) *Reference.*—NavPers 10077, Blueprint Reading.

6. A. C. Theory (30 hours)

(a) *Topics.*—Electric currents and circuits, fundamental units, d. c. circuits, Ohm's Law, Kirchoff's Laws, magnetism and magnetic circuits, electromagnetic induction, capacitors, a. c. voltages, and currents, sine wave and vector relationships, a. c. circuits, single phase voltages and circuits, polyphase voltages and circuits, transformers, polyphase motors, single phase motors, alternators, synchronous motors.

(b) *Text.*—Principles of Electrical Engineering, third edition—Blalock.

(c) *References.*—Mathematics for Electricians and Radiomen—Cooke; Electrical Engineering, volume II—Dawes; Electrical Machinery, third edition—Annett.

7. Thermodynamics (15 hours)

(a) *Topics.*—First and second laws of thermodynamics, properties of substances, Carnot cycle, Rankine cycle, heat transmission, steam plant analysis, pressurizer and degassifier analysis.

(b) *Text.*—Basic Thermodynamics—Brown.

(c) *References.*—Introduction to Nuclear Engineering—Murray Analytical Experimental Physics—Lemon and Ference; steam tables.

B. Plant information (185 hours)

1. Introduction to Nuclear Plants (5 hours)

(a) *Topics.*—History of Nuclear Development—History of Reactor Development—Typical Naval Power Reactor Installation.

(b) *Texts.*—Prepared notes.

(c) *References.*—Smyth Report; Sourcebook on Atomic Energy—Glasstone; Introduction to Nuclear Engineering—Stephenson; Powerplant study manual; manufacturers' instruction books.

2. STR System (100 hours)

(*a*) *Topics.*—(1) Primary systems—main primary loop, hydraulic valves and pilots, pressurizer and degassifier, hydraulic service system, purification system, pressure relief system, sea water purge and coolant leakoff, emergency cooling and emergency injection, charging system, reactor compartment high pressure air system, coolant sampling system, hydrogen addition system, reactor compartment drain and bilge system, shielding, coolant discharge system, salt water and fresh water systems, core construction, rod drive mechanisms, chemical shut down system.

(2) Secondary systems—steam generation, turbine theory and construction, condensers, reduction gear, clutch, lube oil systems, drain systems, hydraulic oil system, evaporators, pure water systems, air conditioning systems, compressed air systems, diesel engines, snorkel, steam plant control.

(3) Electrical systems—D. c. and a. c. distribution systems and functions, power flow analysis, battery, motor generator sets, diesel generators, propulsion motors, turbo generators, circuit breakers and their control, overall electrical system control and functional sequencing, pressure, differential pressure and temperature instrumentation, pressure, level, flow and temperature instrumentation systems, pneumatic instruments—d/p cells, receiver-transmitters, relays, and standatrols, control rod drive, nuclear instrumentation, primary instrumentation, critical control, safety circuits, functional relations, radiation monitoring system.

(*b*) *Texts.*—(1) Primary systems—Powerplant study manual and prepared notes.

(2) Secondary systems—Powerplant study manual, Naval turbines—U. S. Naval Institute; Naval Auxiliary Machinery—U. S. Naval Institute, and prepared notes.

(3) Electrical systems—Vol. IV, Powerplant manual and prepared notes.

(*c*) *References.*—(1) Primary systems—Applicable NavShips and Westinghouse instruction manuals, blueprints.

(2) Secondary systems—Applicable NavShips and Westinghouse instruction books, blueprints.

(3) Electrical systems—Applicable NavShips and Westinghouse instruction books, blueprints.

3. SIR systems (60 hours)

(*a*) *Topics.*—(1) Primary systems: Sodium technology, reactor container, main coolant pumps, steam generators, superheaters, sodium service system, primary valves and interlocks, primary pipe heaters and insulation, third fluid system, leak detection, shielding, control drums and drive mechanisms, salt-water and fresh-water systems, evacuation system, reactor control, reactor instrumentation, core construction, refueling.

(2) Secondary systems: Steam generation, turbine construction, secondary auxiliary systems.

(3) Electrical systems:

(i) D. c. and a. c. distribution systems and functions, d. c. and a. c. power sources and machinery.

(ii) Instrumentation and instrumentation systems.

(iii) Reactor control and radiation monitoring.

(*b*) *Texts.*—(1) Primary systems: Prepared Notes.

(2) Secondary systems: Naval Turbines—United States Naval Institute; Naval Auxiliary Machinery—United States Naval Institute, and Prepared Notes.

(3) Electrical systems: Prepared Notes.

(*c*) *References.*—(1) Primary systems: Applicable NavShips and General Electric Instruction Manuals.

(2) Secondary systems: Applicable NavShips and General Electric Instruction Manuals.

(3) Electrical systems: Applicable NavShips and General Electric Instruction Books.

4. Water technology (10 hours)

(*a*) *Topics.*—Basic definitions, properties of water, corrosion effects in primary system, corrosion product removal from primary system, pure water distillation and treatment, boiler feed water treatment, duties of on board chemist.

(*b*) *Text.*—Prepared notes.

(*c*) *References.*—Handbook of Physics and Chemistary—36th edition; Radiological Health Handbook, United States Department of Health, Education, and Welfare; manufacturers' instruction books.

5. Health physics (10 hours)

(*a*) *Topics.*—History of radiation accidents, basic definitions, types of radiation and their characteristics, radiation measurement, radiation effects on the human body, human exposure tolerances, personnel dosimetry, personnel radiation protection.

(*b*) *Text.*—Prepared notes.

(*c*) *References.*—Sourcebook on Atomic Energy; Glasstone Nuclear Radiation Physics; Lapp & Andrews Radiological Health Handbook; United States Department of Health, Education, and Welfare.

C. Specialized section (200 or 80 hours)

1. Reactor control system (200 hours) (mainly for ET and EM rates)

(*a*) *Topics.*—(1) Electronics with bread boarding: Introduction to control and electronics, review of electricity, Kirchoff's Laws, loop circuits, power and energy, the decibel, alternators, net work simplification, Thevenin's Theorem, Norton's Theorem, superposition theorem, maximum power transfer, nonlinear networks, resistors and conductors, resistance thermometary, special math, inductance, capacitance, R–C and LR circuits, magnetics and problems, rectifiers, vacuum tube theory and amplifiers, vacuum tube lab work, pulse circuits and lab, multivibrators and lab.

(2) Nuclear instrumentation; S–2–W, nuclear instruments, SIR instruments.

(3) Magnetic amplifiers and lab work.

(4) Rod drive and reflector mechanisms, control-rod mechanisms, motors, and MG sets, commutator units, rod programing and control, S–2–W safety circuits, rod motion tests, S–2–W control prints, SIR control.

(5) Reactor poisoning—theory and effects—S–2–W reactor behavior including effect of rods and temperature coefficient, reactor poisoning and effects, effects of core burn up, calculation of estimated critical position, start up procedures, special tests.

(*b*) *Texts.*—Principles of Electrical Engineering—Timbie and Bush; Magnetic Amplifier Circuits—Geyger.

(*c*) *References.*—NavShips 389–0001, Nuclear Instrument Computer Control Group, other applicable NavShips, Westinghouse, and General Electric Instruction Manuals and Blueprints; Introduction to Nuclear Engineering—Murray; The Elements of Nuclear Reactor Theory—Glasstone and Edlund.

2. Plant machinery (80 hours)

(*a*) *Tropics.*—Turbines, condensers, air-condtiioning system, evaporators, machinery control mechanisms, reduction gears, clutch, steam-plant control, thermodynamics.

(*b*) *Texts.*—Power Plant Study Manual; Naval Turbines—United States Naval Institute; Naval Auxiliary Machinery—United States Naval Institute.

(*c*) *References.*—Applicable NavShips and Manufacturers' Instruction Books.

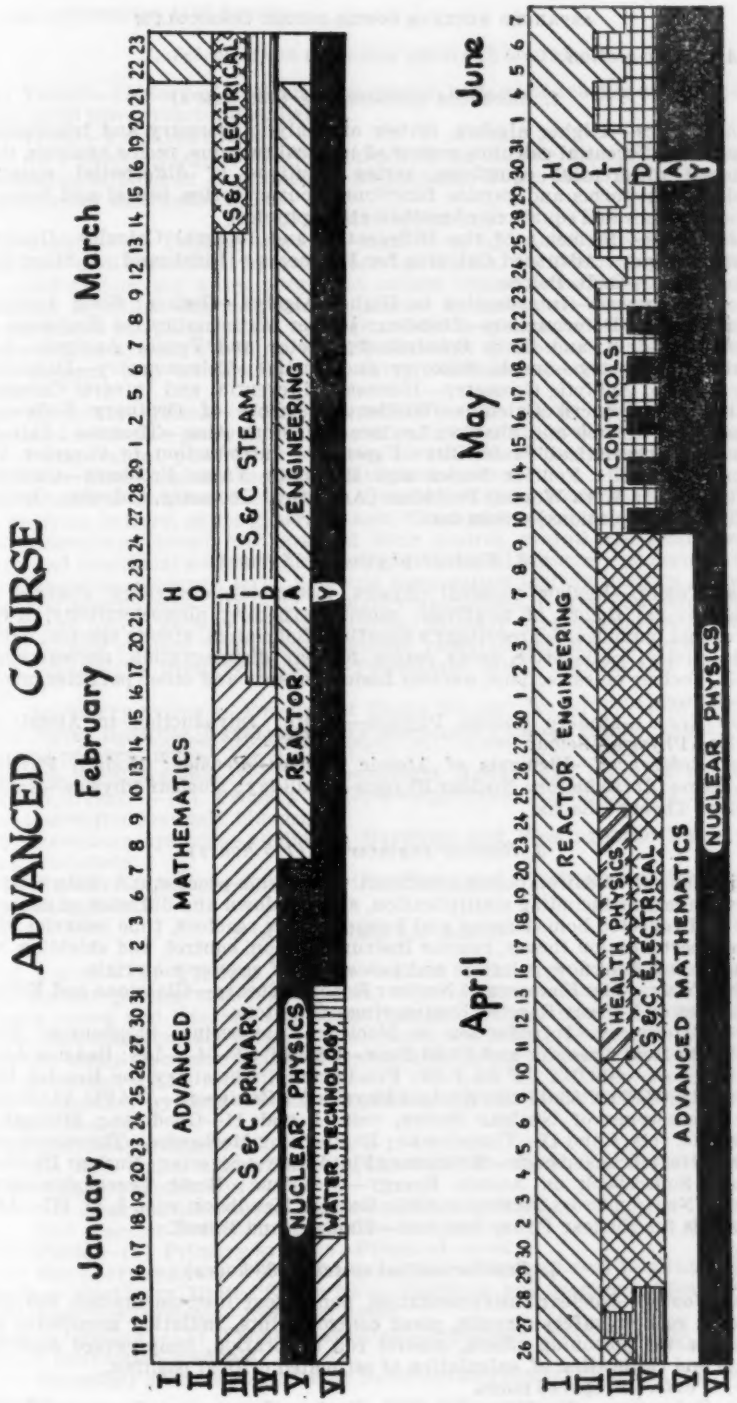
3. Plant Control Systems (200 hours) (alternate for "1. Reactor Control Systems"—mainly for EM and IC rates)

(*a*) *Topics.*—D. c. and a. c. machinery, circuit-breaker construction and operation, under frequency and under voltage relays and circuits, reverse power and reverse current devices, current and voltage transformers and metering, static exciters, saturable reactors, voltage regulators, amplidynes, magnetic amplifiers, valve position indicators, solenoid valves and control, alarm circuits and systems, pneumatic instruments and control systems, steam plant control systems, primary plant control systems, a. c. theory applications.

(*b*) *Texts.*—Power Plant Study Manual.

(*c*) *References.*—Westinghouse and General Electric instruction books.

(It should be noted that the Plant Machinery portion of the Specialized Section terminates 140 hours (4 weeks) early in order to allow selected EN and MM rates to leave early for stainless steel welding training.)


ADVANCED COURSE
January
February
March
April
May
June
ADVANCED MATHEMATICS
HOLIDAY
S & C PRIMARY
S & C STEAM
S & C ELECTRICAL
NUCLEAR PHYSICS
WATER TECHNOLOGY
REACTOR ENGINEERING
CONTROLS
HEALTH PHYSICS
S & C ELECTRICAL
ADVANCED MATHEMATICS
NUCLEAR PHYSICS
I II III IV V VI

ADVANCED NUCLEAR POWER COURSE CURRICULUM

A. Academic section

1. Advanced mathematics (135 hours)

(*a*) *Topics.*—Higher algebra, review of analytic geometry and trigonometry, review of differential calculus, review of integral calculus, vector analysis, linear ordinary differential equations, series solutions of differential equations, Laplace transforms and gamma functions, Fourier series, initial and boundary value problems and equations of mathematical physics.

(*b*) *Texts.*—Elements of the Differential and Integral Calculus—Granville, Smith, Longley; Advanced Calculus for Engineers—Hildebrand; A Short Table of Integrals.—O. B. Peirce.

(*c*) *References.*—Introduction to Higher Algebra—Bocher; Solid Analytical Geometry and Determinants—Dresden; Higher Mathematics for Engineers and Physicists—I. S. and E. S. Sokolnikoff; Vector and Tensor Analysis—Lass; Analytic Geometry—Smith, Salkover and Justice; Trigonometry—Dadourian; Calculus and Analytic Geometry—Holmes; Differential and Integral Calculus—Franklin; Advanced Calculus—Widder; Elements of Ordinary Differential Equations—Golomb and Shanks; Laplace Transformation—Thomson; Introduction to Mathematical Probability—Uspensky; Introduction to Complex Variables—Churchill; Fourier Series and Boundary Value Problems—Churchill; Outline Series With Worked Problems (Analytical Geometry, Calculus, Ordinary Differential Equations)—Schaum.

2. Nuclear physics (135 hours)

(*a*) *Topics.*—Review classical physics, mechanics, electricity, charged particles, special theory of relativity, atomic structure, photoelectricity, X-rays, waves and particles, Schroedinger's equation, Bohr atom, atomic spectra, natural radioactivity, radioactive decay series, nuclear disintegration, nuclear energy levels, nuclear cross sections, nuclear fission, mesons and other particles, nuclear accelerators.

(*b*) *Texts.*—Modern College Physics—White; Introduction to Atomic and Nuclear Physics—Semat.

(*c*) *References.*—Elements of Atomic Physics—Peaslee; Modern Physics—Van Name; Introductory Nuclear Physics—Halliday; Nuclear Physics—Kaplan; Nuclear Theory—Sachs.

3. Reactor engineering (145 hours)

(*a*) *Topics.*—Neutron physics, radioactivity, fission process and chain reaction, reactor analysis including multiplication, slowing down and diffusion of neutrons, bare and reflected homogeneous and heterogeneous reactors, time behavior of reactors, perturbation theory, reactor instrumentation, control, and shielding, heat transfer and fluid flow, selection and processing of reactor materials.

(*b*) *Texts.*—The Elements of Nuclear Reactor Theory—Glasstone and Edlund; Principles of Nuclear Reactor Engineering—Glasstone.

(*c*) *References.*—Introduction to Nuclear Engineering—Stephenson; Introduction to Heat Transfer and Fluid Flow—OSORT CF–54–8–168; Reactor Analysis, Notes on—OSORT CF 54–7–88; Fundamental Chemistry for Reactor Engineers—OSORT CF 53–11–22; Nuclear Physics for Engineers—WAPD–10; Science and Engineering of Nuclear Power, vols. I and II—Goodman; Strength of Materials, vols. I and II—Timoshenko; Engineering Mechanics—Timoshenko and Young; Heat Transmission—McAdams; Fluid Flow—Streeter; Nuclear Physics—Fermi; Sourcebook on Atomic Energy—Glasstone; Basic Thermodynamics—Brown; Neutron Cross Sections—AEC; Reactor Handbook, vols. I, II, III—AEC; Materials for Nuclear Power Reactors—Hausner and Rokoff.

4. Reactor control systems (30 hours)

(*a*) *Topics.*—Nuclear instrumentation, nonnuclear instrumentation, rod drive systems, reactor safety circuits, plant control prints, radiation monitoring systems, reactor poisoning effects, control rod calibration, temperature coefficient effects and calibration of, calculation of estimated critical position.

(*b*) *Texts.*—Prepared notes.

(*c*) *References.*—NavShips 389–0001, Nuclear Instrument Computer Control Group, other applicable BuShips and manufacturers' instruction manuals, blueprints.

B. Plant information (185 hours)

1. *Introduction to nuclear plants* (5 hours)

(*a*) *Topics.*—History of nuclear development, history of reactor development, typical naval power reactor installation.
(*b*) *Texts.*—Prepared notes.
(*c*) *References.*—Smyth Report; Sourcebook on Atomic Energy—Glasstone; Introduction to Nuclear Engineering—Stephenson; Powerplant Study Manual; manufacturers' instruction books.

2. *STR system* (100 hours)

(*a*) *Topics.*—(1) Primary systems—main loop, hydraulic valves and pilots, pressurizer and degassifier, hydraulic service system, purification system, pressure relief system, sea water purge and coolant leakoff, emergency cooling and emergency injection, charging system, reactor compartment high pressure air system, coolant sampling system, hydrogen addition system, reactor compartment drain and bilge system, shielding, coolant discharge system, salt water and fresh water systems, core construction, rod drive mechanisms, chemical shut down system.
(2) Secondary systems—steam generation, turbine theory and construction, condensers, reduction gear, clutch, lube oil systems, drain systems, hydraulic oil system, evaporators, pure water systems, air conditioning systems, compressed air systems, diesel engines, snorkel, steam plant control.
(3) Electrical systems—d. c. and a. c. distribution systems and functions, power flow analysis, battery, motor generator sets, diesel generators, propulsion motors, turbo generators, circuit breakers and their control, overall electrical system control and functional sequencing, pressure, differential pressure and temperature instrumentation, pressure, level, flow and temperature instrumentation systems, pneumatic instruments—d/p cells, receiver-transmitters, relays, and standatrols, control rod drive, nuclear instrumentation, primary instrumentation, critical control, safety circuits, functional relations, radiation monitoring system.
(*b*) *Texts.*—(1) Primary systems—Powerplant Study Manual and prepared notes.
(2) Secondary systems—Powerplant Study Manual, Naval Turbines; United States Naval Institute, Naval Auxiliary Machinery; United States Naval Institute; and prepared notes.
(3) Electrical systems—vol. IV, Powerplant Manual and prepared notes.
(*c*) *References.*—(1) Primary systems—Applicable NavShips and Westinghouse instruction manuals, blueprints.
(2) Secondary systems—Applicable NavShips and Westinghouse instruction books, blueprints.
(3) Electrical systems—Applicable NavShips and Westinghouse instruction books, blueprints.

3. *SIR systems (60 hours)*

(*a*) *Topics.*—(1) Primary systems—sodium technology, reactor container, main coolant pumps, steam generators, superheaters, sodium service system, primary valves and interlocks, primary pipe heaters and insulation, third fluid system, leak detection, shielding, control drums and drive mechanisms, salt water and fresh water systems, evacuation system, reactor control, reactor instrumentation, core construction, refueling.
(2) Secondary systems—steam generation, turbine construction, secondary auxiliary systems.
(3) Electrical systems:
(i) D. c. and a. c. distribution systems and functions, d. c. and a. c. power sources and machinery.
(ii) Instrumentation and instrumentation systems.
(iii) Reactor control and radiation monitoring.
(*b*) *Texts.*—(1) Primary systems—Prepared notes.
(2) Secondary systems—Naval Turbines, United States Naval Institute; Naval Auxiliary Machinery, United States Naval Institute, and prepared notes.
(3) Electrical systems—Prepared notes.
(*c*) *References.*—(1) Primary systems—Applicable NavShips and General Electric instruction manuals.
(2) Secondary systems—Applicable NavShips and General Electric instruction manuals.
(3) Electrical systems—Applicable NavShips and General Electric instruction books.

4. Water technology (10 hours)

(*a*) *Topics.*—Basic definitions, properties of water, corrosion effects in primary system, corrosion product removal from primary system, pure water distillation and treatment, boiler feed water treatment, duties of on-board chemist.

(*b*) *Text.*—Prepared notes.

(*c*) *References.*—Handbook of Physics and Chemistry, 36th edition; Radiological Health Handbook, United States Department of Health, Education, and Welfare; manufacturers' instruction books.

5. Health physics (10 hours)

(*a*) *Topics.*—History of radiation accidents, basic definition, types of radiation and their characteristics, radiation measurement, radiation effects on the human body, human exposure tolerances, personnel dosimetry, personnel radiation protection.

(*b*) *Text.*—Prepared notes.

(*c*) *References.*—Source book on Atomic Energy, Glasstone; Nuclear Radiation Physics, Lapp and Andrews; Radiological Health Handbook, United States Department of Health, Education, and Welfare.

APPENDIX 2

Training for Medical Officers and Hospitalmen

A. SCOPE OF NEW CURRICULUM FOR MEDICAL OFFICERS FOR NUCLEAR PROPULSION PROGRAM (TENTATIVE)

Subjects	Laboratory hours	Lecture hours
Introduction to power reactor problems		10
Mathematics review		50
Physics, general review		35
Nuclear physics		65
Radiochemistry	75	50
Radiation instrumentation	100	80
Radiobiology		80
Health physics	150	100
Subtotal	325	470
Total hours	795	

Mathematics review (50 hours)

1. Refresher on algebra and trig and exponentials (10 hours)
2. Differential calculus (10 hours)
3. Survey of integral calculus (5 hours)
4. Differentnial equations (20 hours)
5. Rate equation (emphasis on problems) (5 hours)

Physics general review (35 hours)

(Humphreys and Beringer as textbook)

1. Particle dynamics
2. Heat and kinetic theory.
3. Periodic motions
4. Electrostatics
5. Circuits
6. Basic electronics
7. Brief survey of atomic physics

Nuclear physics (95 hours)

(Lapp and Andrews as textbook)

1. Brief summary of chapters 1, 2, 3
2. Follow book:
   - Chapter 4—Atomic Structure
   - Chapter 5—X-Rays
   - Chapter 6—Natural Radioactivity
   - Chapter 7—Isotopes and Nuclear Structure
   - Chapter 8—Types of Nuclear Radiation
   - Chapter 9—Ionization Chamber Instruments
   - Chapter 10—Geiger-Muller Counters
   - Chapter 11—Radiation Measurement Technique
   - Chapter 12—Artificial Radioactivity
   - Chapter 13—Nuclear Reactions
   - Chapter 14—The Neutron
   - Chapter 15—Nuclear Fission
   - Chapter 16—The Nuclear Chain Reaction
3. Reactor engineering (15 hours)

Radio chemistry course (50 hours, lecture)

Text, Friedlander and Kennedy—Introduction to Radio Chemistry
(emphasis on understanding radiochemistry and separations techniques)

A. Use the following chapters in Friedlander:
   - Chapter 1—General Discussion of Radioactivity
   - Chapter 10—Techniques for Measurement and Study of Radiation
   - Chapter 11—Identification, Concentration, and Isolation of RA Species
   - Chapter 12—Chemistry of Low Concentrations.
   - Chapter 13—Tracers in Chemistry Applications

   (The omitted chapters deals with atomic structure, RA decay, and instrumentation covered by other courses.)

B. Follow with brief series of lectures on practical problems by contractor or AEC personnel:
   1. Reactor water chemistry, particularly radiochemical aspects
   2. Same for sodium
   3. Details on radiochemical measurements required for the following situations:
      - (*a*) Startup of new plant
      - (*b*) Routine operation
      - (*c*) Waste disposal
   4. Importance of radiochemical measurements to reactor plant operation

C. Lab course (75 hours).
   1. Review chemical analytical techniques
   2. Review counting instrumentation
   3. Study counting techniques
   4. Study chemical separations
   5. Work up unknowns using practical examples

Radiological Instrumentation (150 hours, lectures and laboratory)

A. Principles of radiation detection and measurement:
   - (*a*) Radiation detection:
     1. Ionization chambers
     2. The G–M Counters
     3. Proportional Counters
     4. Scintillation Counters
     5. Fast neutron Counters
     6. Termal neutron counters
     7. Fission counters
     8. Photographic film dosimetery
     9. Phosphate glass dosimetery
     10. Chemical dosimetery
     11. Neutron foils and nuclear films
   - (*b*) The electronics of radiation measurement:
     1. The vacuum tube and principles of amplification
     2. The photo-multiplier tube
     3. Transistor amplifiers

Radiological Instrumentation (150 hours, lectures and laboratory)—Continued

4. Magnetic amplifiers
5. Pulse amplifier circuits and characteristics
6. Multi-vibrator, Bianary and Decade scaler circuits
7. Complete counter and scaler systems
8. The principles of count rate meters
9. Electrometer amplifier circuits
10. Power supplies and voltage regulators

(*c*) Review of complete laboratory counting systems:
1. Alpha counting equipment
2. Beta counting equipment
3. Gamma counting equipment
4. Neutron counting equipment
5. Multi-channel analyzers

(*d*) The special problems of portable radiation equipment:
1. Alpha, beta, gamma, and neutron detectors
2. Miniature vacuum tubes and special circuits
3. Batteries and vibrator power supplies
4. General description and applications

Radiobiology (50 hours lecture)

1. Introduction to biological effects of radiation:
   (*a*) History of biological damage: (1) Dial painting, (2) radium mining, (3) medical radiology, (4) nuclear incidents
2. Radiation effects on biochemical systems
3. Effects on blood and bloodforming organs
4. Hemorragic phenomena of radiation
5. Effects on the alimentary tract
6. Effects on the gonads
7. Effects on the skin and eye
8. Effects on the bones
9. Effects on the total body
10. Immunalogy and infection
11. Radiation in stress
12. Factors modifying response to radiation
13. Induction of tumors by radiation
14. The aging effects of radiation
15. Radiation significance in shortening the life span
16. The genetic effects of radiation
17. Effects of internally deposited radioactive materials on the body organs

Health physics (100 hours lectures, 150 hours lab and field work)

1. The purpose and function of radiation control:
   (*a*) In industry
   (*b*) In the Atomic Energy Commission
   (*c*) In the Department of Defense
2. The basis for maximum permissible exposures:
   (*a*) Radiological terminology: (1) X-rays, gamma rays, beta rays, alpha rays, neutrons, dose, dosage rate, the rad, the rep, the roentgen, the air dose, tissue dose, half-value layer, specific ionization, RBE, etc.
   (*b*) Radiobiological considerations: (1) Radiosensitivity, variability, recovery and repair, genetic effects, life span, effect of age, etc.
   (*c*) Maximum permissible weekly exposures: (1) Occasional exposure, long-term exposure, occupational and nonoccupational exposure, internal and external exposure, technical overexposure
   (*d*) Radiation protection regulations: (1) NBS hnadbooks, National Committee on Radiation Protection, International Commission on Radiation Protection, AEC Legal Licensing Regulations, Interstate Commerce Regulations, etc.
3. Maximum permissible internal exposures:
   (*a*) Maximum permissible concentrations in air, food, and drinking water
   (*b*) Special cases in radioactive gases
   (*c*) Theory and calculations of internal exposures

Radio chemistry course (50 hours, lecture)—Continued

4. Health physics monitoring and survey:
   (*a*) Type of monitoring instruments. Use, calibration, circuits, repair, energy response, etc.
   (*b*) Survey methods and procedures. For research, industry, atomic defense, and power-reactor plants.
   (*c*) Air sampling for particulate and gaseous activity
   (*d*) Wipe or smear tests for removable activity
   (*e*) Food and water samples.
   (*f*) Ecological surveys
5. Laboratory analysis of survey samples:
   (*a*) Types of equipment required
   (*b*) Calibraton and use
   (*c*) Methods and calculations
   (*d*) Decay curve measurements
   (*e*) Absorption curve measurements
   (*f*) Radiochemical analysis of urine and solid wastes
   (*g*) Air sample counting and calculations
   (*h*) Radon breath samples
6. Personnel monitoring instruments and their use:
   (*a*) Pocket ion chambers
   (*b*) Film dosimeters
   (*c*) Phosphate glass dosimeters
   (*d*) Chemical dosimeters
   (*e*) Film finger rings
7. Medical examinations:
   (*a*) Preexposure examinations
   (*b*) Physical requirements
   (*c*) Followup examinations
   (*d*) Overexposure to external and internal radiation
   (*e*) Removal of persons from radiation exposure
   (*f*) Separation examinations
8. Treatment of radiation injuries:
   (*a*) Treatment of contaminated wounds
   (*b*) The use of chelating compounds
   (*c*) Plasma and antibotics
9. Decontamination:
   (*a*) Sources of contamination
   (*b*) General principles of decontamination
   (*c*) Natural decay
   (*d*) Detergents and wetting agents
   (*e*) Chelating agents and special chemicals
   (*f*) Preventative measures
   (*g*) Personnel protection
   (*h*) Permissible levels of contamination
10. Protective clothing and equipment:
   (*a*) Special clothing, respirators, etc.
11. Transportation of radioactive materials:
   (*a*) Interstate Commerce Commission regulations
   (*b*) Packaging and labeling
   (*c*) Post office regulations
   (*d*) Air express and air freight
   (*e*) Protection of personnel and photographic film
12. The disposal of radioactive wastes:
   (*a*) Regulations of the NRCP and AEC
   (*b*) Incineration
   (*c*) Burial
   (*d*) Disposal at sea
   (*e*) Authority and responsibility
   (*f*) Liquid wastes to rivers and subsurface streams
   (*g*) Cost and future problems.

B. BILLET DESCRIPTION OF HOSPITAL CORP PERSONNEL ASSIGNED TO NUCLEAR SUBMARINES

1. Must meet all requirements for submarine hospitalman.

2. Have appreciable knowledge of nuclear physics and basic nuclear engineering principles. Nuclear physics to include thorough understanding of the periodic table, artificial and natural radioactivity, radioactivity decay schemes, ionization, radiation absorption, nuclear reactions, neutron induced reactions, fission, nature of fission products, neutron cross sections, shielding, radiation detection and measuring principles, and necessary mathematics.

Nuclear engineering to include basic power-reactor systems, heat transfer systems and materials used, nature of reactor coolants, and their associated radiation problems, coolant activities induced by radiation, associated waste disposal problems. Reactor system auxiliaries, particularly those associated with radiation hazard such as resin purification, filters, charging systems, principles of reactor control, hazards inherent in steam systems from the standpoint of airborne activity. Radiation problems during maintenance and repair of contaminated components.

3. Understand thoroughly the biological effects of radiation, radiation units, roentgen, rep, rem, rad, curia, RBE, flux. Nature of tissue ionization including tissue neutron absorption. Tolerances, both external and internal, and factors influencing permissible tolerance exposures. Tissue sensitivity in general and special problems such as eye and gonadal exposure.

4. Understand and perform basic clinical laboratory procedures including complete blood counting, blood typing and cross matching, complete urinalysis including radiation-counting procedures on urine, bacteriological staining and microscopic identification of common bacteria. Use standard apparatus including glassware, centrifuge, evaporation equipment, standard and darkfield microscope with oil-immersion technique.

5. Possess a thorough knowledge of medical department administrative procedures, particularly maintenance of adequate records and logs relating to radiation exposure.

6. Be able to establish a complete well integrated radiation hygiene program to cover both radiation problems on board nuclear submarines in repair, overhaul, or construction. This shall include:

(*a*) Formulate written orders and directives governing procedures and techniques to be followed by personnel serving in above categories. Carry out necessary lectures and instructions of an indoctrination nature to crewmen. Establish and carry out basic training courses for emergency radiation monitors in casualty situations.

(*b*) Establish and fully maintain a complete photodosimetry program capable of interpretation and evaluation of beta, gama, thermal and fast neutron, and mixed radiation exposures. Procure, issue, process, read, interpret, and record radiation data obtained from both beta-gamma and neutron sensitive film. Calibrate such film utilizing, radium, cobalt 60, uranium, radium-beryllium sources. Be familiar with the effects of shielding, back scatter, and electronic equilibrium in such calibrations, and be capable of performing the necessary mathematical computations. Have a thorough knowledge of film response and film variation as regards energy, filtration, stability, storage conditions and processing procedures. Operate densitometers and microscopes used in photodosimetry techniques, and calibrate and adjust this equipment. Issue, read, charge, and maintain pocket dosimeters, both neutron and gamma sensitive types. Thoroughly understand the dose range, energy dependence, response, and accuracy of those instruments.

(*c*) Operate radiation survey meters—beta-gamma, thermal neutron, fast neutron, and alpha sensitive types, both Navy supplies and common commercial types. Understand the variables inherent in each type particularly in relation to accuracy, sensitivity, variation of response with energy, directional characteristics, discriminating ability in mixed fluxes, and range of dose. Calibrate such equipment, make necessary correction curves, and perform necessary tests on equipment to insure its operational readiness and accurate functioning. Be capable of minor repairs, such as replacement of batteries and tubes. Interpret surveys from the standpoint of work-time determinations and detection of operational casualties and advise the commanding officer on potential exposure risk.

7. Measure airborne particle activity by portable and fixed collection devices. Understand the effects of filter efficiency, flow rate, sampling time and location of sampling devices and sensitivity of such determinations. Understand the nature of internal injestion hazard from airborne radioactivity, and the variation in internal tolerance values between radioisotopes due to the nature of the element, biological affinities, physical and biological half-life. Know the basic mechanics of constant air-monitoring systems and their limitations, particularly from the standpoint of sensitivity and accuracy, qualitatively and quantitatively. Make recommendations as to type of respiratory protection required in all situations and thoroughly understand the mechanisms and limitations of filter masks, air-supplied masks, and other respiratory protective devices. Be able to interpret and evaluate the levels of airborne radioactivity from natural sources, in order to distinguish between radon and other airborne radioisotopes. Special techniques for gases such as Argon 41.

8. Perform and interpret radioactive counting procedures utilizing both Geiger-Mueller and scintillation techniques. Prepare all types of samples for counting procedures. Determine G. M. tube plateaus, compute geometry, backscatter, absorption, resolving time, and coincidence loss with standard sources. Understand basic statistics of counting techniques and perform necessary mathematical computations. Utilize half-life and beta absorption studies for identification of unknown radioisotopes, and quantitative determinations of activity. Use feather plot for beta energy determinations, recognize malfunction of counting equipment, and make minor repairs and adjustments.

9. Procure, maintain, and distribute protective clothing. Understand the varying requirements for protective clothing as determined by situational evaluation. Establish monitoring points in contaminated areas and change stations for protective clothing.

10. Understand the principles of recognition and treatment of personnel decontamination. Use standard and special techniques such as chelating agents for external decontamination. Use nasal swabs as a means of qualitative estimate of internal exposure. Treat contaminated wounds and know the importance of the degree and type of contamination in such wounds. Understand the principles of good conservative treatment versus radical techniques in wound contamination.

11. Understand basic principles of material contamination control aboard operating ships. Make necessary recommendations as to methods of material decontamination. Determine the nature, degree, and spread of radioactive contamination. Know techniques of decontamination and understand the limitations and associated hazard of decontamination procedures aboard ships.

APPENDIX 3

Tables of Contents of Some of the Reactor Technology Handbooks Prepared by Naval Reactors Branch and Its Contractors

LIQUID METALS HANDBOOK

(Edited by Richard N. Lyon; second edition, June 1952; 269 pp.)

Table of contents

Chapter 1. Industrialization utilization of liquid metals—Donald L. Katz.
Chapter 2. Physical properties of liquid metals—R. R. Miller.
Chapter 3. Chemical properties and laboratory techniques—Carey B. Jackson and Roy M. Adams.
Chapter 4. Corrosion of materials by liquid metals—Edward C. Miller.
Chapter 5. Liquid-metal heat transfer—Richard N. Lyon and H. F. Poppendiek.
Chapter 6. Experimental liquid-metal heat-transfer systems—Thomas Trocki.
Chapter 7. Liquid-metal experimental heat-transfer system components—Thomas Trocki.
Chapter 8. Availability of liquid metals—I. R. Kramer.

SODIUM-NaK SUPPLEMENT

(Edited by Carey B. Jackson; third edition, July 1955)

Table of Contents

Chapter 1. Properties

Chemical properties, physical properties

Chapter 2. Fundamentals

Heat transfer

Natural circulation, forced convection, boiling, condensation

Chemical engineering

Purity and purification, inert gas, leak detection, liquid sodium-water reactions, radioactive material transfer, behavior of sodium in graphite

Chapter 3. System design

Materials and fabrication, flow characteristics, thermal stress and thermal stress fatigue, piping considerations, thermal insulation, operation and maintenance.

Chapter IV. Components

Heat exchangers and steam generators, pumps (electromagnetic pumps and mechanical pumps), valves, instrumentation, combustion heating, cooling

Chapter V. Safety and fire protection

Non-radioactive sodium, radioactive sodium

Chapter VI. Applications

Genie project, MSA high temperature system, EBR heat transfer experience

METALLURGY OF ZIRCONIUM

(Edited by Benjamin Lustman and Frank Kerze, Jr.; first edition, 1955)

Table of contents

Chapter 1. Zirconium and Its Application to Nuclear Reactors, by H. Etherington, R. C. Dalzell, and D. W. Lillie

History, Application of Zirconium to Nuclear Reactors, Nuclear Reactors (3.1 Cross Sections and Neutron Absorption, 3.2 Nuclear Changes, 3.3 Fission and Nuclear Fuel, 3.4 Criticality, 3.5 Neutron Economy, 3.6 Moderators, 3.7 Coolant or Heat-Transfer Medium), Nuclear Properties of Zirconium, Other Properties of Zirconium (5.1 Hafnium in Zirconium, 5.2 Other Impurities in Zirconium), Desirable Nonnuclear Properties of Zirconium (6.1 Corrosion Resistance, 6.2 Mechanical Properties, 6.3 Modified Zirconium), Use of Zirconium in Reactors (7.1 Permanent Structure. 7.2 Zirconium-Uranium alloys, 7.3 Clad)

Chapter 2. Application of Zirconium for Other Uses, by R. I. Jaffee

Introduction, Chemical Equipment (2.1 Hydrochloric Acid, 2.2 Spinnerts, 2.3 Applications at the United States Bureau of Mines, Albany, Oreg., 2.4 Other Mediums), Electric and Electronic Uses (3.1 Vacuum Tubes, 3.2 Electrolytic Condensers and Rectifiers, 3.3 Point-Contact Rectifiers, 3.4 Miscellaneous Electrical Uses), Use of Zirconium as an Alloying Addition (4.1 Ferrous Alloys, 4.2 Magnesium Alloys, 4.3 Aluminum Alloys, 4.4 Copper Alloys, 4.5 Nickel Alloys), Zirconium Compounds (5.1 Zircon, 5.2 Zirconia, 5.3 Zirconium Diboride, 5.4 Zirconium Carbide and Nitride), Miscellaneous Uses (6.1 Glass-to-Metal Seals, 6.2 Spot Welding and Brazing, 6.3 Pyrophorics, 6.4 Surgical Uses)

Chapter 3. Occurrence of Zirconium, by M. H. Kline

Geographic Location of Deposits, Estimate of Reserves, Future Requirements, Hafnium Contents of Various Materials, Mining and Ore-Dressing Methods, Ore Produced in Past Years.

Chapter 4—Zirconium Production Methods, edited by S. M. Shelton.

Thermodynamic Properties of Zirconium Compounds (Introduction, Zirconium and Hafnium Dioxides, Zirconium and Hafnium Carbides, Zirconium and Hafnium Nitrides, Zirconium Silicate, Zirconium and Hafnium Halides, Phosphorus Oxychloride Complexes of Zirconium and Hafnium Tetrachlorides, Compounds of Interest in Zirconium-reduction Processes).

Kroll Process (History, Theory of the Reduction Process, Production Techniques (11.1) Carbide Production, 11.2 Carbonitride Production, 11.3 Oxide Production, 11.4 Chlorination, 11.5 Densification of the Tetrachloride, 11.6 Tetrachloride Purification and Reduction, 11.7 Sponge Processing, Future Developments).

Other Processes (Reduction of Zirconium Tetrachloride with Sodium, Calcium, or Magnesium, Reduction of the Fluoride with Calcium or Magnesium, Reduction of Alkali Fluozirconate with Sodium or Aluminum, Reduction of Zirconium Oxide with Calcium, Magnesium, or Aluminum, Reduction of Zirconium Oxide with Carbon or Zirconium Carbide, Fusion Electrolysis of Chloride or Fluoride Baths, Electrolysis of Aqueous and Organic Solutions).

Hafnium Removal (Discovery and History, General Chemistry, Methods of Separation (22.1 Fractional Crystallizations, 22.2 Fractional Precipitation, 22.3 Fusion Methods, 22.4 Distillation Separations, 22.5 Thermal Decomposition, 22.6 Separation by Ion Migration, 22.7 Ion Exchange, 22.8 Adsorption Separation, 22.9 Solvent-extraction Separations).

Chapter 5—Iodide-decomposition Process for Production of Zirconium, by Z. M. Shapiro.

Introduction, History, The Deposition Process, Corrosion of Materials in an Iodine Atmosphere, Design of Metal Deposition Vessel, Method of Filament Attachment, Auxiliary Equipment (7.1 Constant-Temperature Bath, 7.2 Power Supply, 7.3 Filament Temperature Control), Method of Addition of Iodine or Zirconium Iodide, Experimental Results (9.1 Rate of Growth vs. Filament Temperature, 9.2 Variation of Deposition Rate with Type of Feed Material, 9.3 Effect of Inert Gas on Growth Rate, 9.4 Variation of Growth Period with Varying Quantities of ZrI_4, 9.5 Variation of Deposition Rate with Bath Temperature, 9.6 Factors Determining Crystal-bar Purity), Practical Production Methods (10.1 The Foote Mineral Co. Plant, 10.2 the WAPD Plant) Disadvantages of the Iodide Process and Possible Future Improvements (11.1 Cheap Alternate Feed Material, 11.2 Iodine Recovery, 11.3 Continuous Processes).

Chapter 6—Melting and Shaping of Zirconium and its Alloys, Edited by R. B. Gordon.

Melting of Zirconium (Historical Background, Arc Melting (2.1 Introduction, 2.2 Nonconsumable-Electric Arc Melting, 2.3 Consumable-Electrode Arc Melting, 2.4 General), Induction Melting (3.1 General, 3.2 Crucibles for Melting Zirconium, 3.3 Carbon Pickup from Graphite Crucibles, 3.4 Induction-melting Furnaces, 3.5 Melting and Casting Practice), Resistance Melting (4.1 General, 4.2 Description of Furnace, 4.3 Operation of Furnace), Drip Melting (5.1 General, 5.2 Description of Method, 5.3 Results, 5.4 Uses), Autocrucible Melting (6.1 General, 6.2 Description of Method, 6.3 Results), Potential Melting Techniques (7.1 General, 7.2 Float Melting, 7.3 Skull Melting), Recovery of Scrap (8.1 General, 8.2 Recovery of Solid Scrap, 8.3 Recovery of Machine Scrap).

Fabrication of Zirconium (Early Small-Scale Fabrication Methods, General Fabricating Characteristics, Heating for Hot Working, Ingot Fabrication, Hot Rolling, Cold Rolling, Extrusion (15.1 General, 15.2 Sheath Extrusion, 15.3 Bare Extrusion, 15.4 Consolidation), Swaging, Rod and Wire Drawing, Deep Drawing and Cupping, Tube Fabrication (19.1 Tube Drawing, 19.2 Swaging and Tubing, 19.3 Tube Reducing, 19.4 Tube Forming by Welding), Annealing of Zirconium.

Powder Metallurgy of Zirconium (Introduction, Leaching Zirconium Sponge, Kinetics of the Reaction of Hydrogen with Zirconium, Powder Preparation, Compacting of Zirconium and Zirconium Hydride Powders, Sintering of Zirconium and Zirconium Hydride, Hot Pressing of Zirconium Powder, Properties of Sintered Zirconium, Preparation of Zirconium Alloys by Powder Metallurgy).

Chapter 7—Joining and Finishing of Zirconium.
Joining (Arc Welding (1.1 Welding Techniques, 1.2 Properties of Welded Joints), Resistance Welding, Solid-Phase Welding (3.1 Roll Cladding, 3.2 Swaging and Drawing, 3.3 Powder-Metallurgical Techniques), Brazing), Finishing (Machining (5.1 Milling, 5.2 Turning, 5.3 Drilling, 5.4 Punching, 5.5 Fires), Grinding, Surface Treatment and Cleaning (7.1 Vapor Blasting, 7.2 Cleaning, 7.3 Pickling), Plating (8.1 Electroplating on Zirconium, 8.2 Surface Preparation for Brazing and for Hot-dip Coating, 8.3 Chemical Polishing, 8.4 Electroplating).

Chapter 8—Physical metallurgy of zirconium and its alloys, by A. R. Kaufmann and T. T. Magel.
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Chapter 9—Zirconium Alloy Systems, edited by E. T. Hayes.
Introduction, Theoretical Survey (2.1 Size of the Atom, 2.2 Relative Size of Ion, 2.3 Valency of Zirconium, 2.4 Brillouin Zones, 2.5 Electrochemical Character and Polarizability, 2.6 Summary of Theoretical Factors), Purity of Alloys, Methods (4.1 Metallography, 4.2 Thermal Analysis, 4.3 Melting Point, 4.4 X-Ray Diffraction, 4.5 Miscellaneous), Types of Diagrams, Zirconium Equilibrium Diagrams (6.1 Zirconium Alkali and Alkaline-earth Metals, 6.2 Zirconium-Aluminum, 6.3 Zirconium-Antimony, -Arsenic, and -Bismuth, 6.4 Zirconium Beryllium, 6.5 Zirconium-Boron, 6.6 Zirconium-Cadmium, 6.7 Zirconium-Carbon, 6.8 Zirconium-Chromium, 6.9 Zirconium-Cobalt, 6.10 Zirconium-Copper, 6.11 Zirconium-Germanium, 6.12 Zirconium-Gold, 6.13 Zirconium-Hafnium, 6.14 Zirconium-Hydrogen, 6.15 Zirconium-Indium, 6.16 Zirconium-Iron, 6.17 Zirconium-Lead, 6.18 Zirconium-Magnesium, 6.19 Zirconium-Manganese, 6.20 Zirconium-Mercury, 6.21 Zirconium Molybdenum, 6.22 Zirconium-Nickel, 6.23 Zirconium-Niobium, 6.24 Zirconium-Nitrogen, 6.25 Zirconium-Oxygen, 6.26 Zirconium-Platinum Group Metals, 6.27 Zirconium-Selenium, 6.28 Zirconium-Silicon, 6.29 Zirconium-Silver, 6.30 Zirconium-Tantalum, 6.31 Zirconium-Thorium, 6.32 Zirconium-Tin, 6.33 Zirconium-Titanium, 6.34 Zirconium-Tungsten, 6.35 Zirconium-Uranium, 6.36 Zirconium-Vanadium, 6.37 Zirconium-Zinc).

Chapter 10—Mechanical Properties of Zirconium and its Alloys, by W. Chubb, G. T. Muehlenkamp, F. R. Shober, and A. D. Schwope; edited by F. Forscher.
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Chapter 11—Corrosion of Zirconium and its Alloys, edited by Benjamin Lustman.

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Corrosion in Water and Steam (Introduction (7.1 Scope, 7.2 Testing Methods, 7.3 Corrosion of Unalloyed Zirconium in Water, 7.4 Corrosion of Unalloyed Zirconium in High-temperature Steam, 7.5 Corrosion of Zirconium-base Alloys in Water and Steam, 7.6 Mechanism of Corrosion).

Corrosion in Acids, Bases, and Salts (Early Investigations, High-hafnium Induction-Melted Zirconium (9.1 Results with Inorganic Acids, 9.2 Results with Base, 9.3 Results in Inorganic Salts, 9.4 Results in Organic Compounds), Effect of Zirconium Purity on Corrosion Resistance (10.1 Tests in Hydrochloric Acid, 10.2 Miscellaneous Tests), The Corrosion Resistance of Zirconium Alloys (11.1 Tests in Hydrochloric Acid, 11.2 Alloys with Relatively Low Zirconium Content, 11.3 Tests in Fuming Nitric Acid and Other Acids), Tabulation of Corrosion Properties, Corrosion in Fused Salts.

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Electrode Reactions of Zirconium Metal (Introduction, General Mechanism of the Anodic Process on Zirconium, Effect of Electrolytes on the Behavior of Zirconium (18.1 Effect of Concentration of Nitric Acid, 18.2 Properties of Thin Films, Phenomena Observed With Thick Films), Cathodic Reactions).

Chapter 12—Analytical Chemistry of Zirconium, by E. B. Read

Introduction, Problems Associated With Analysis of Zirconium-Base Metals (2.1 Sampling of Zirconium Metal, 2.2 Preparation of Samples for Analysis), Problems Associated With Chemical Analysis of Zirconium, Separation of Zirconium (4.1 Precipitation, 4.2 Extraction, 4.3 Volatilization, 4.4 Ion Exchange), Chemical Analysis for Impurities in Zirconium Metal (5.1 Aluminum, 5.2 Boron, 5.3 Cadmium, 5.4 Chromium, 5.5 Copper, 5.6 Iron, 5.7 Lead, 5.8 Magnesium, 5.9 Manganese, 5.10 Molybdenum, 5.11 Nickel, 5.12 Titanium, 5.13 Tungsten, 5.14 Vanadium, 5.15 Zinc, 5.16 Carbon, 5.17 Chlorine, 5.18 Phosphorus, 5.19 Silicon, 5.20 Oxygen, 5.21 Hydrogen, 5.22 Nitrogen), Zirconium Alloys, Spectrographic Analysis of Zirconium Metal (7.1 Introduction, 7.2 Analysis for Impurity Elements, 7.3 Analysis for Alloying Elements. 7.4 Analysis for Rare-Earth Elements, 7.5 Analysis for Low Concentrations of Hafnium, 7.6 Analysis for High Concentrations of Hafniun), Pile-Activation Techniques (8.1 Introduction, 8.2 Induced Radioactivity, 8.3 Experimental Procedure, 8.4 Results).

Appendix A—Metallography of Zirconium, by H. P. Roth.

General History of Metallographic Procedures, Sample Preparation (2.1 Mechanical Polishing, 2.2 Chemical Polishing, 2.3 Electropolishing, 2.4 Etching), Alloying Elements and Impurity Particles, Photography (4.1 Photography in Bright Field, 4.2 Photography in Polarized Light), Use of Polarized Light for Zirconium Metallography, Electron Metallography of Zirconium.

Appendix B—Industrial Hygiene and Safety, by E. E. Barnes.

Introduction, Explosion Hazard, Fire Control, Shipment, Toxicity, Miscellaneous.

Appendix C—Engineering Data Sheets.

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Appendix D—Glossary.

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(Edited by D. W. White, Jr., and J. E. Burke; first edition, 1955)

Chapter I. Introduction, by C. B. Sawyer and B. R. F. Kjellgren
Chapter II. Importance of Beryllium:
*A. Historical Note on Sources and Uses of Beryllium, by R. F. Griffith
*B. The Role of Beryllium in the Atomic Energy Program, by R. E. Pahler
*C. The Role of Beryllium in Industry, by N. W. Bass
Chapter III. Ores:
A. Occurrence of Beryllium Ores and Their Treatment, by W. R. Griffitts and J. J. Norton
Chapter IV. Reduction:
A. Thermodynamic Considerations in the Preparation of Beryllium Metal, by H. H. Kellogg
*B. The Fluoride Extraction of Berrylium From Beryl, by H. C. Kawecki
*C. The Sulphate Extraction of Beryllium From Beryl, by C. W. Schwenzfeier, Jr.
D. The Production of Beryllium by the Electrolysis of Beryllium Chloride, by C. E. Windecker
E. Experimental Reductions of Beryllium, by T. T. Magel
Chapter V. Fabrication (chapter editor, H. H. Hirsch):
A. The Melting and Casting of Beryllium, by P. Corzine and A. A. Kaufmann
*B. Fabrication of Beryllium by Powder Metallurgy, by W. W. Beaver
C. Research and Development in Beryllium Powder Metallurgy, by H. H. Hausner and N. P. Pinto
*D. Mechanical Working of Beryllium by Extrusion, by P. Loewenstein, A. R. Kaufmann, and S. V. Arnold
*E. Mechanical Working of Beryllium by Rolling, Forging, and Similar Processes, by S. M. Bishop
F. Machining of Beryllium, by L. Duran
*G. Joining of Beryllium, by D. C. Martin
*H. Plating and Cladding of Beryllium, by J. T. Stacy
Chapter VI. Properties:
A. The Physical and Mechancial Properties of Beryllium Metal, by D. W. Lillie.
B. The Nuclear Properties of Beryllium, by J. R. Stehn.
Chapter VII. The Brittleness Problem (chapter editor, A. R. Kaufmann):
*A. The Relation of Purity to Brittleness in Beryllium, by A. R. Kaufmann.
*B. Ductility of Beryllium as Related to Single Crystal Deformation and Fracture, by G. L. Tuer and A. R. Kaufmann.
*C. Ductility of Beryllium as Related to Preferred Orientation and Grain Structure, by J. L. Klein, V. Macres, D. Woodard, and J. Greenspan.
D. Recovery and Recrystallization of Cold Worked Beryllium, by G. L. Tuer, D. H. Woodard, D. B. Lister, and A. R. Kaufmann.
Chapter VIII. Metallography:
*A. Metallography of Beryllium and Beryllium-Rich Alloys, by M. C. Udy.
Chapter IX. Corrosion* (Chapter editor, R. F. Koenig):
A. Corrosion of Beryllium in Air, by J. L. English.
B. Corrosion of Beryllium in Water, by J. L. English.
C. Corrosion of Beryllium in Liquid Metals, by R. F. Koenig.
Chapter X. Alloys:
*A. Berryllium-Rich Alloys, by A. R. Kaufman and P. Corzine.
Chapter XI. Cermets and Ceramics:
*A. Refractory Compounds and Cermets of Beryllium, by W. W. Beaver.
*B. The Refractory Properties of Beryllium Oxide, by J. F. White.
Chapter XII. Health Hazards:
*A. Health Hazards from Beryllium, by M. Eisenbud.
Chapter XIII. Analytical Chemistry:
A. Analytical Chemistry of Beryllium, by C. J. Rodden and F. A. Vinci.
Name index.
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*Papers presented in part at Beryllium Conference, ASM midwinter meeting, Boston, March 4–5, 1954.

A BIBLIOGRAPHY OF AVAILABLE DIGITAL COMPUTER CODES FOR NUCLEAR REACTOR PROBLEMS

(By A. Radkowsky and R. Brodsky; October 14, 1955)

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MUFT-III	IBM-650
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RE–21	AVIDAC
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CHAIM	UNIVAC
TEMP	UNIVAC
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Long term Irradiation of Nuclear Fuels (B)	IBM 701 (Duel Code) (Floating Point Arithmetic)
BURPP	UNIVAC
BURPPE	UNIVAC
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REACTOR SHIELDING DESIGN MANUAL

Edited by Theodore Rockwell III; first edition, March 1, 1956

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CORROSION AND WEAR HANDBOOK FOR WATER-COOLED REACTORS

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NUCLEAR PLANT PIPING HANDBOOK

Edited by Milton Shaw; first edition scheduled December 1956)

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2. Importance of subject: Safety aspects. Size of major piping components. Impact on arrangements. Shielding considerations. Stresses—thermal, vibratory, and shock. Cleanliness. Tightness. Remoteness of components. Quantity of special fittings. Inspection features. New arts and standards. Standards for maintenance and repair. Decontaminability.

Chapter II. Materials (including weld metals):
(Cross-reference: Material Control, sec. VIII)
1. Discussion of factors involved in selection of piping materials: (*a*) Cost and availability. (*b*) Ease of fabrication. (*c*) Radioactive activation. (*d*) Corrosion resistance. (*e*) Decontaminability. (*f*) Mechanical properties. (*g*) Radiation damage. (*h*) Prior experience—(1) Code acceptance, (2) Past use.
2. Trade designation and schedules: Raw material includes comprehensive mechanical-geometric properties of standard sizes (i. e., flexural moments of inertia, flow areas, etc.). Also schedules for weld metals and rod conformation to cover commercially available tube and pipe such as (1) seamless (pierced, extruded); (2) welded; (3) cast (for high pressure system).
3. Metallurgy: (*a*) Chemical constitutions. (*b*) Heat treat, etc., practice. (*c*) Raw stock inspection techniques (summary) (cross reference with sec. III). (*d*) Summaries on solid solutions and plastic action—theory. (*e*) Welding metallurgy—base metal action.
4. Qualification: (*a*) Tests on raw stock. (*b*) Tests on finished material.
5. Material properties: (*a*) Static strength. Stress-strain diagrams—selected materials. Tabulation for selected materials—proportional limit, elastic limit, yield point, ultimate strength, elongation, Poisson's ratio, etc. Static properties at elevated temperatures, including creep and rupture data. Failure criteria. Notch and other stress concentration effects. Influence of welding on mechanical properties. (*b*) Dynamic properties. Modification of stress strain relationships as function of speed of loading. Fatigue, endurance limit, tabulation, combined static and dynamic loads, Soderberg diagrams, etc. Internal damping. Corrosion fatigue. (*c*) Action under thermal shock (effect of material type). (*d*) Plastic performance (by material type). (*e*) Heat transmission properties. Specific heats, conductivities, etc. (including variations of properties with temperature). (*f*) Radiation properties. Summaries of neutron and gamma radiation action—scattering, absorbtion, cross sections, half lives, etc. Emphasis on variance in materials. (Cross-reference with Shielding handbook.)
6. Corrosion, erosion and cavitation: (*a*) Brief description of actions as to material and contamination effects. (*b*) Descriptive-trend tabulation by material type.
7. Surface finish: (*a*) Significance—erosion and corrosion effects. (*b*) Shop practices including bends and fittings. (*c*) Summary on economics. (*d*) Flow, heat transfer, and cleanliness effects.
8. Bibliography

Chapter III—Design standards:

1. Integrity: (*a*) History of failures—locations in pipe systems, failure types; operating conditions at failures; stress histories of failed systems. (*b*) Correlation of failures and calculations. (*c*) Stress concentration effects. (*d*) Current systematic endeavors, probability studies, etc. (*e*) Future investigations and objectives.
2. Codes: (*a*) Intent. (*b*) Codification history—Brief. (*c*) Descriptive—salient features and applicability of military and civil codes including inspection codes. (*d*) Legal and insurance status—(1) Shipboard plants, (2) land installations—regional variations. (*e*) Special specifications. (*f*) Superposition of specifications—code conflicts. (*g*) Welders' qualification standards. (*h*) Plant standards. (*i*) Special topics on compliance with codes—(1) Superposition of design conditions, (2) vendor plant inspection—certificates, processing, (3) ultrasonic techniques—descriptive—production aspects, (4) X-ray examination—leg sample and 100 percent, (5) other techniques—dye check, magnaflux, etc.
3. Waiver of codes: (*a*) Reasons—history—special operating requirements; reduced safety standards; compliance with basic intent of code; functional variances, etc. (*b*) Administrative handling of waivers.
4. References

Chapter IV.—Piping Joints:

1. Welding, casting, and seamless construction: (*a*) Essential design features (including manufacturing)—descriptive. (*b*) Assets and liabilities of each. (*c*) Factors of workmanship. (*d*) Effect on fitting types.
2. Welding: (*a*) Suitability of conventional practice and advances in techniques. (*b*) Types of joints—backing rings, consumable inserts, etc. (straight, elbow, tee, etc., features). (*c*) Procedure forms (cross-reference with sec. II). (*d*) Surface preparation—bevel angles, clearance, etc; tools and machining practice; cleanliness, etc. of faying surfaces. (*e*) Welding rods—storage, marking and handling. (*f*) Location of work—shop welds. Off location welding—on ship. Field welds. (*g*) Welding planning—weld identification diagrams—joint designations. Checkoff procedure. Mockup team precheck. (*h*) Bimetallic connections—stainless—carbon. Stainless—Monel. Carbon Steel—Monel. Cu-Ni—stainless. Ni-cu stainless. Weld metals. "Buttering" of faying edges, intermediate passes, etc. Special inspection features, thermal cycling, etc. (*i*) Techniques of welding—sequencing. Positioning of work. Voltage, amperage, current, and polarity. Preheat. Interpass temperatures. Interpass cleaning. Tacking techniques. Bead widths. Field weld techniques (finish weld contraction). (*j*) Weld inspection (cross-reference with sec. II). (*k*) Strength of welds (including base metals). (*l*) Welding and dimensional stability of fittings (i. e. valve seats, etc.). (*m*) Welder qualifications—plant practices. Specification (cross-reference with sec. II). Training. Classification.
3. Flanges and gaskets: (*a*) Types of joints (including experience with special fittings). (*b*) Tightness requirements. (*c*) Bolting—size, number, torque, disposition, etc. (*d*) Strength of flanges—action under flexure, torsion and pressure loading (including bolt group action and local bending). (*e*) Flanged bimetallic joints. (*f*) Flange standards. (*g*) Gasket material (including specification reference). (*h*) Gasket types (geometry). (*i*) Installation and reinstallation practice. (*j*) Flanged joint testing.
4. Special joints: Sliding, rotating and compression joints.
5. Joint selection: Corrosion and other considerations.

Chapter V. Fabrication, Assembly and Testing:

1. Pipe, tube and fitting manufacture.
2. Marking and tagging.
3. Storage and plant transportation features—inventory control, open stock practice, etc. (See Material Control, sec. VIII.)
4. Fabrication and assembly planning.
5. Pipe shop—features.
6. Pipe bending—shop machines; quality of labor; hot and cold springing; out size vendor-furnished bends, storage, inspection handling.
7. Shop testing (i. e., vacuum tightness, burst, helium—mass spectrometer measurements etc.).
8. Dimensioning from piping plans—allowable variances.
9. Templating from ship.

Chapter V—Contiued

10. Subassembly and on-board, off-location work.
11. Cleanliness standards (Cross-reference with sec. II).
12. Structural penetrations.
13. Final shipboard fitting.
14. Pipe identification—by service and type (on-board), including tests.
15. Installed cleanliness; final inspections and tests.
16. Insulation—material and installation practice.
17. Fittings, standard fittings—handling and assembly features. Special fittings—production aspects. Special tests. Certification. Hanger and snubber manufacture and installation.
18. Accessibility factors.
19. At-sea inspection and repair.
20. Removal and reinstallation (including reinstallation tests for cleanliness, tightness, integrity, etc.).
21. References.

Chapter VI. Fluid Mechanics:

1. Brief theory: (*a*) Laminar, transition, turbulent-smooth, turbulent-transition, completely rough performance. (This is to be descriptive to show basic effects on pressure drop and heat transfer.) (*b*) Significant dimensionless groupings—Reynolds Number; Nusselt Number; Grashoff Number, etc. (*c*) Convection flows—brief theoretical description including transient aspects; practical aspects— heat centers, ship inclination effects, "cold legs," emergency cooling features. (Plant start up and shut down) with respect to forced flow, natural convection, local circulation, etc. (*d*) Flow through bends, sudden enlargements and contractions (diffuser design).
2. Pressure drop: (*a*) Orders of precision to be expected. (Note differences due to fitting types, percentage of straight pipe, etc.). Stress need for sense of proportion. Need for error estimate ("expected" versus "recommended" information). (*b*) Straight pipe and bends. Darcy and other formulas. Moody and Rouse Formulations (suggest inclusion). Discussion of catalog-type information. Standards and incertitudes of absolute roughness measures (diagram to show significance). Equivalent K concept. (*c*) Fittings reportage; equivalent length versus K concepts. (1) Standard fittings; effects of small variations; display chart to show K values of representative fittings of a group of selected authorities. (Could be overlay on equivalent K chart of selected straight pipes for various fluid types and conditions.) (2) Special fittings: Estimates (using sudden enlargement or contractions): probable errors of estimates; tests. (3) Effects of close groupings of fittings. (*d*) Pressure drops through major equipment items. (Estimates, errors, and tests as per (3) above). (Include publishable history.) (*e*) Tests: Planning, instrumentation, care in handling, repeatibility. (*f*) Suggested future work.
3. Heat transfer: (*a*) Brief description heat transfer through laminar and turbulent boundary layers—variables involved: fluid state effects. (*b*) Wall and insulation-heat transfer—brief summary. (*c*) Mean temperature differences—computation procedures. (*d*) Overall heat transfer coefficients. (*e*) Precision estimates. (*f*) Cross-reference on liquid metal, conduction, etc., effects, etc. (*g*) Influence on natural circulation. (*h*) Suggested future work. (*i*) Selected tabulation—density, specific heat, viscosity, etc., data.
4. System dynamic stability (i. e. pressurizing, charging systems).
5. Bibliography.

Chapter VII. Stress analysis, vibration and shock:

1. Static Stress Analysis: (*a*) Introduction showing considerations that must be analyzed (i. e. pressure loading of pipe and fittings, distributed vs. concentrated loads, expansion stress and flexibility of pipe and components etc.). (*b*) Outline elastic theory of space frames (including generalized method for thermal action, common to all techniques); influence coefficients; orders of static indeterminacy; basic assumptions (including material property selections). Uncertitudes in way of fittings; effects of manufacturing eccentrics of bore; error studies. (*c*) Outline—very basic matrix algebra. Emphasize convenience of matrices. (*d*) Rigorous methods. (1) Kellogg method—essential features. (2) Brock-Matrix method—essential features. (3) Compara-

Chapter VII—Continued

tive discussion. (4) Significant detail common to both methods (i. e. valves, wyes, etc.). (*e*) Hand and short-cut methods. (1) Spievlogel. (2) Zeno-Vinieratos. (3) Schack (three dimensional) for orthogonally disposed systems. (*f*) Discussion—general assets and limitations. (*g*) Economics and Time Factors. Influence of automatic computation—economics of same; stress analysis as a production item—scheduling; staff requirements (not including machine programers); time and cost estimating. (*h*) Stress estimating (for preliminary design efforts) tabulation of past efforts; need for stress trend studies; need for guidance rules for combinations (i. e., bending vs torsional load paths, direct tensile and flexural shear significance, multi branch effects, skewness effects, maximum stress—probable loci, effects of semifixed constraints, relationships of possible dominant free movements, etc.). (*i*) Programing for automatic computation. Close interlock between economics and technology. Essence of digital computation. Input and output types. Data storage features—possibilities of economics. Standardizing of subroutines. Mathematicians and programers—leadership. Communication with engineering groups. Consultation services—economies of same. Program filing. Planning for trend studies. General computation planning. Optimum utilization of machines. Servicing of machines. (*f*) Models for static stress analysis. Description of successful methods. Pitfalls (i. e., fitting stresses, unreal constraints, etc.). Scale. Material factors. Degree of faithfulness. Corner and fitting effects—simulation. Security of constraints simulation. Loading techniques. Measuring instruments. Expected degree of precision. Economics. (*k*) Working stress levels. Correlation with failure theory (see sec. II). (*l*) Full-size tests. History and desirability. Instrumentation. Implications of results. (*m*) Flexibility and stress analysis of attaching equipment items. Special reference to boiler, turbine, and pressure vessel nozzles. (*n*) Analysis of piping in partially plastic state. Plastic hinge concept. Bi-axial yielding. Possibilities in analysis of "reduced elastic structures". Desirable future work. (*o*) Practical stress effects: Welding stresses, effect of manufacturing tolerances (eccentrics), fitting stresses. (*p*) Accuracy of above calculation techniques. (*q*) Nomenclature. Tabulation of authorities' notation. Suggestions on standardization.

2. Vibration: (*a*) Importance—special reference to safety requirements of nuclear plants, to remoteness and to large number of possible excitation sources and devious transmission modes. (*b*) Essential types of vibration—elastic solid action. Elastic fluid action. (*c*) Stimuli—support motion—induced. Alternating external forces. Fluid-borne pressure variations. (*d*) Natural frequencies and normal modes. Essential features—static property information required. Concept of generalized coordinates and forces. (*e*) Elastic solid action. Techniques—natural frequency and mode calculation (i. e., Iteration, Rayleigh, secular differences, etc.); discussion. Characteristic responses—influence of direction of stimuli. Damping—estimates and need for more data. Forced steady state vibration—differential equation type and solution forms. Vibratory stresses. (*f*) Elastic fluid action. Basic wave equation(s) Influence of specific geometrics (resonators, coupling, etc.). Vibration modes. Overpressures. Transfer and other impedances. (*g*) Dynamic models. Purpose—essentially natural frequency only. History—expected accuracy.

3. Shock (mechanical): (*a*) Test experience—design philosophy (near-lethal standoffs). (*b*) Features of: Explosion and bubble history. Interface impingement and hull response—pressure time-history. (*c*) Elements of response of simple and complex elastic bodies to impulses, step function and discrete disturbance (expressed as time history). (*d*) Significance of shock spectrum—an approximate description of stimulus. (*e*) Significance of starting velocity—a still further approximation of stimulus. (*f*) Outline of mathematical forms expressing shock response. (*g*) Shock stresses—calculation methods—types. Influence of probability. Orders of precision. Designing to limiting stresses (enveloping the solutions). Need for automatic computation. Conservatism. (*h*) Yielding in the presence of shock (discussion—Plastic hinge concepts, reduced elastic system, plastic-rigid analyses,

Chapter VII—Continued
etc. (*i*) Approximation by uniform windage-type loading (constant G method). Refer—methods of static stress analysis. Special limitations for bodies with distributed compliance and mass. (*j*) Mechanical impact. (*k*) Water hammer action (reference 2 (f)). (*l*) Usefulness of electrical analogies. (*m*) Need for further work.
4. Shock (thermal). (*a*) Importance of analysis. (*b*) Analysis of temperature and stress distributions. (*c*) Empirical data on thermal strain fatigue. (*d*) Present and future work.
5. Bibliography

Chapter VIII. Layouts and production design
1. Objectives: (*a*) To investigate: (1) Accessibility. (2) Minimum shielding. (3) Minimum liquid volume. (4) Minimum pressure drop (5) Operational feasibility. (*b*) To compare competing arrangements.
2. Arrangement considerations: (*a*) Effect of compartment location and plant operation. (*b*) Type of loop. (1) Expansion. (2) Strut. (3) Semi-strut. (*c*) Support and foundation. (1) Keyways. (2) Trunnions. (3) Hangers. (4) Snubbers. (5) Buffers. (*d*) Assembly features. (*e*) Weights of system and centers of gravity. (*f*) Shielding. (1) Techniques. (2) Contamination. (*g*) Auxiliary systems. (*h*) Emergency cooling requirements. (*i*) Safeguards aspects.
3. Methods of evaluation: (*a*) Layouts. (*b*) Graphical and photographic techniques. (*c*) Mockups (full size and scale).

APPENDIX 4

Procedure and Criterion for Qualification as a Chief Operator at the Naval Reactor Test Facility, Arco, Idaho

I. A candidate for chief operator will, upon assignment as a candidate, trace out personally all systems necessary to complete the drawings listed below. Several systems must be traced from blueprints since they are inaccessible in the hull, but in every case, the candidate must know the location of each valve, breaker, or component of the system concerned by having personally visited the equipment in question. As long as a candidate has personally traced a system in order to fulfill the drawing requirements for a watch station, he has fulfilled the requirements for that drawing in this qualification. Upon completion of a drawing or drawings, the candidate will deliver them to his shift supervisor for correction and acceptance.

The drawings required are as follows:
1. Primary systems, including:
   (*a*) Primary loop
   (*b*) Emergency heat exchangers
   (*c*) Hydraulic service system
   (*d*) Purification system
   (*e*) Pressurizer and degasifier system
   (*f*) Charging system
   (*g*) Drain and relief system
   (*h*) Pilot valve system—list all hydraulic operated valves together with type of pilot valve used.
   (*i*) Emergency injection system
   (*j*) Chemical shutdown system
2. Steam system
3. Boilers, including:
   (*a*) Boiler blowdown system
   (*b*) Reliefs
4. Feed and condensate systems
5. Steam drain systems
6. Electrical system (one line AC and DC)
7. HP air systems, including emergency air system
8. 500-pound and 350-pound air systems
9. Control air systems, including:
   (*a*) 85-pound air
   (*b*) 40-pound air
   (*c*) 28-pound air
   (*d*) 15-pound air
   (*e*) Reducing station

10. Reactor compartment salt water and fresh water system
11. Sound powered telephone system
12. High pressure hydraulic system
13. Low pressure hydraulic system
14. Chilled water system
15. Lube oil filling and transfer system, including purifier
16. Main lube oil system
17. CTG lube oil system
18. EPM lube oil system
19. Main circulating water system
20. CTG circulating water system
21. EPM circulating water system
22. Air conditioning circulating water system
23. Dumping condenser circulating water system
24. 4,000 GPD evaporator system
25. Freon system
26. Diesel lube oil system
27. Diesel fuel oil system, including purifier
28. Diesel fresh water system
29. Diesel salt water system
30. Motor starter locations
31. Electrical breaker locations
32. Electrical load lists, including:
    (*a*) Reactor compartment vital
    (*b*) Reactor compartment ship's service
    (*c*) Engineroom vital
    (*d*) Engineroom ship's service
33. Reactor control block diagram
34. 840-cycle set and regulator block diagram
35. Electrical diagram of rod drive MG sets, bussing, and rod motors
36. Nuclear instrumentation component layout
37. Rod programming circuit schematic
38. Radiation monitoring system block diagram
39. Emergency shutdown system schematic (show alarm, scram panel and scram amplifier as blocks)
40. Thimble cooling system
41. Neutron shield tank fill and drain system

II. Upon completion of all drawings, a candidate will stand at least four 4-hour watches under instruction during critical operations in each of the hull and water brake watch stations. He will also stand at least four 4-hour watches under instruction at each of the 2-floor watch stations. The candidate will also perform three startups by actually operating the reactor controls from source level to about 3 percent power level. A candidate who has previously qualified as an operator on a station has fulfilled this requirement for that station.

III. The candidate will then, upon completion of watches as indicated in paragraph II, be assigned as an assistant chief operator. He will learn the methods and procedures of operating the plant as a whole under the direct supervision and instruction of the chief operator. When he has completed all the practical factors listed below and his shift supervisor feels that he is qualified to be a chief operator, the shift supervisor will recommend to the supervisor of operations that the candidate be examined for the positions.

The practical factors listed below will be accomplished by every candidate at some time during the time that he is making drawings or standing instruction watches. If a candidate has already done a practical factor as part of his qualification as an operator, the performance of that practical factor at this time is considered fulfilled.

A. Reactor compartment:

1. Operate all electrical equipment locally and shift starters to remote.
2. Operate degasifier heaters locally.
3. Line up and operate fresh water system.
4. Line up and operate salt water system.
5. Set the spray control flow valves and the demineralizer flow valves.
6. Line up the valve function box normally and operate valves.
7. Line up the steam and feed systems.
8. Line up the steam drain systems.
9. Control boiler level locally while steaming.

10. Demonstrate how to operate the standby condensers locally.
11. Blow down the boilers using all methods.
12. Inject chemicals into the boilers.
13. Manually operate the lower level boiler drain valves.
14. Cross connect fresh water system to lower level spot coolers.
15. Split the steam feed and condensate systems and cross connect.
16. Take boiler water samples.
17. Fill the neutron shield and annulus tanks.
18. Operate the emergency heat exchanger 6-inch valves.
19. Pressurize and vent the emergency heat exchangers manually.
20. Line up and operate the charging system.
21. Operate the emergency injection system, refill the water flasks, recharge the air bank.
22. Complete the startup checkoff sheet.
23. Backflush the hydraulic service filter or strainer, both externally and internally.
24. Demonstrate how to operate the chemical shutdown system.
25. Line up the primary makeup water demineralizer.
26. Demonstrate how to start and secure a feed water heater.
27. Line up backup breakers.

B. Engineroom:
1. Line up the main steam system, shift to and from site operation.
2. Line up and operate the steam drain system.
3. Line up and operate the condensate system, shift to and from site operation.
4. Line up and operate the five circulating water systems.
5. Line up, start, and stop the diesel engine.
6. Line up, start, and stop the lube oil and fuel oil purifiers.
7. Line up and operate the lube oil filling and transfer system.
8. Line up and operate the engineroom air systems.
9. Operate the reactor compartment drain manifold.
10. Start and stop the evaporator.
11. Start and stop one air conditioning set.
12. Start and stop one control air compressor.
13. Operate all electrical equipment locally and shift starters to remote.
14. Demonstrate how to operate turbine throttles locally.
15. Complete the startup checkoff sheet.
16. Demonstrate line up of port bleed steam system.
17. Demonstrate proper method of controlling turbine lube oil temperatures, generator air temperatures, MG set air temperatures, condenser circulating water temperature rise, and EPM air temperature.
18. Operate the air ejectors.

C. Maneuvering room:
1. Start and stop the electric propulsion motor in series and in parallel.
2. Warm up the main turbine.
3. Engage and disengage the clutch electrically. Demonstrate how it is done manually.
4. Operate the turning gear.
5. Start and operate the TG sets.
6. Control surge tank level and boiler level manually.
7. Start, parallel, and stop the 150 kilowatt MG sets.
8. Parallel and load the TG sets.
9. Operate the main coolant pumps.
10. Operate the 15-cycle sets.
11. Operate the Arco tie feeder panel.
12. Load the diesel generator.
13. Line up the safety cooling pump.
14. Shift lighting between ERV and ERSS.
15. Line up the backup breakers.
16. Operate the RSPP nonnuclear equipment controls.
17. Complete the startup checkoff.

D. Water brake:
1. Maintain turbine load and speed.
2. Line up and operate lube oil system.
3. Line up and operate circulating water system.
4. Line up and operate air system.
5. Start, operate, and stop the recorders.

E. Miscellaneous:
1. Line up the dumping condenser.
2. Start and secure the dumping condenser air ejectors.
3. Start and stop emergency diesels locally, shift to auto.
4. Start and stop high pressure air compressors, shift to auto.
5. Complete the floor startup checkoff.

F. Chief operator:
1. Control the plant from a cold, shutdown condition to 100 percent power and return, using both cold startup and hot startup methods. Warm the plant and cool the plant in accordance with current operating instructions.
2. Maneuver the plant from battery creep, steam dead, to 100 percent power and return in accordance with current operating procedures.

IV. The examination for qualification as chief operator will be administered by the supervisor of operations, a shift supervisor other than the one who recommended the candidate, and a qualified chief operator. The examination may be either written or oral. Part of the examination will consist of a tour through the hull to demonstrate the candidate's complete and accurate knowledge of the physical location of piping, valves, instruments, and components. The remainder of the examination will consist of specific questions designed to determine the extent of the candidate's working knowledge and ability to control and operate the plant. Knowledge of design, clearances, tolerances, and other minor construction features of components is not required. Complete familiarity of the identity and function of the components is required. Knowledge of major construction features, capacities, speeds, and horsepower of components is required as necessary to operate the plant and its systems properly. The fields of knowledge that are required are listed below:

A. Complete and accurate working knowledge of:
1. The reactor, including heat evolution; critical position; effect of fission products; coefficients of reactivity due to temperature, pressure, and flow; poison buildup and burnup in transients; knowledge of period; stability; core structure; nuclear instrumentation, and control system.
2. The primary system including valves and piping, components, electrical controls, circuitry, instrumentation, and shielding.
3. The steam system including valves and piping, components, instrumentation, and controls and circuitry.
4. The feed and condensate systems including valves and piping, components instrumentation, and controls and circuitry.
5. The circulating water systems including valves and piping, components, instrumentation, and controls and circuitry.
6. The air systems including valves and piping up to instrument supplies, components other than instruments, controls and circuitry, and system instrumentation.
7. Bailey instruments.
8. The lube oil systems including valves and piping, components, instrumentation, and controls and circuitry.
9. The steam drain system, including valves and piping and components.
10. The reactor compartment fresh water and salt water system, including valves and piping, components, instrumentation, and controls.
11. The hydraulic oil systems including valves and piping, components, instrumentation, and controls.
12. The air-conditioning freon and chilled water systems including valves and piping, components, instrumentation, and controls.
13. The evaporator and its associated systems, including valves and piping, components, instrumentation, and controls.
14. The diesel engine and its associated systems, including valves and piping, components, instrumentation, and controls.
15. The electrical distribution system, including breakers, cabling, instrumentation, controls, and circuitry.
16. The radiation monitoring system, including detectors, display, normal levels, and alarm levels.
17. The communications systems.
18. The neutron shield tank filling and thimble pump cooling systems, including valves and piping, components, and controls.

B. Familiarity with and good working knowledge of:
1. Site boilers.
2. Site diesels.

3. Pump house equipment, including circulating water pumps and floor circulating water system, holding tank, retention basins, associated pumps, valves, and piping.
4. Effluent system, including valves and piping, instrumentation, and controls.
5. Floor makeup water system including valves and piping, components, and instrumentation.
6. Floor electrical distribution system including load banks, breakers, and control circuitry.
7. Water brake including valves and piping, components, instrumentation, and controls.
8. Sample house and sampling system.

C. A complete and accurate working knowledge of all control circuitry including the understanding of the interlocks and sequencing systems that govern the control of each piece of equipment. This includes a working knowledge of the pressure switch settings for automatic operation.

D. A complete knowledge of the effect on the plant of a change in a system or component.

E. A complete knowledge of normal plant operating conditions, as shown by instrumentation, which enables the candidate to interpret, correctly and rapidly, a change in instrumentation indication. This includes a full and complete knowledge of normal and limiting values of flow, current pressure, and temperature.

F. A complete and accurate knowledge of all current standing orders, operating procedures, and safety precautions.

G. A thorough understanding of the casualty control procedures as evidenced by accurate knowledge of the proper steps necessary to control a casualty.

V. If upon completion of the above requirements the supervisor of operations is satisfied that the candidate has a thorough knowledge of the plant, and that he is fully capable of controlling the plant and the watch standers under all operating conditions, he may designate the candidate as a qualified chief operator. Upon such designation, the manager, STR test facility, will send a certification to the Chief PAFO, stating that the candidate has been designated as a qualified chief operator of the STR test facility in accordance with this criterion. This qualification shall remain in effect for not more than 1 year at which time requalification must be established.

APPENDIX 5

NUCLEAR TRAINING AT THE PORTSMOUTH NAVAL SHIPYARD, PORTSMOUTH, N. H.

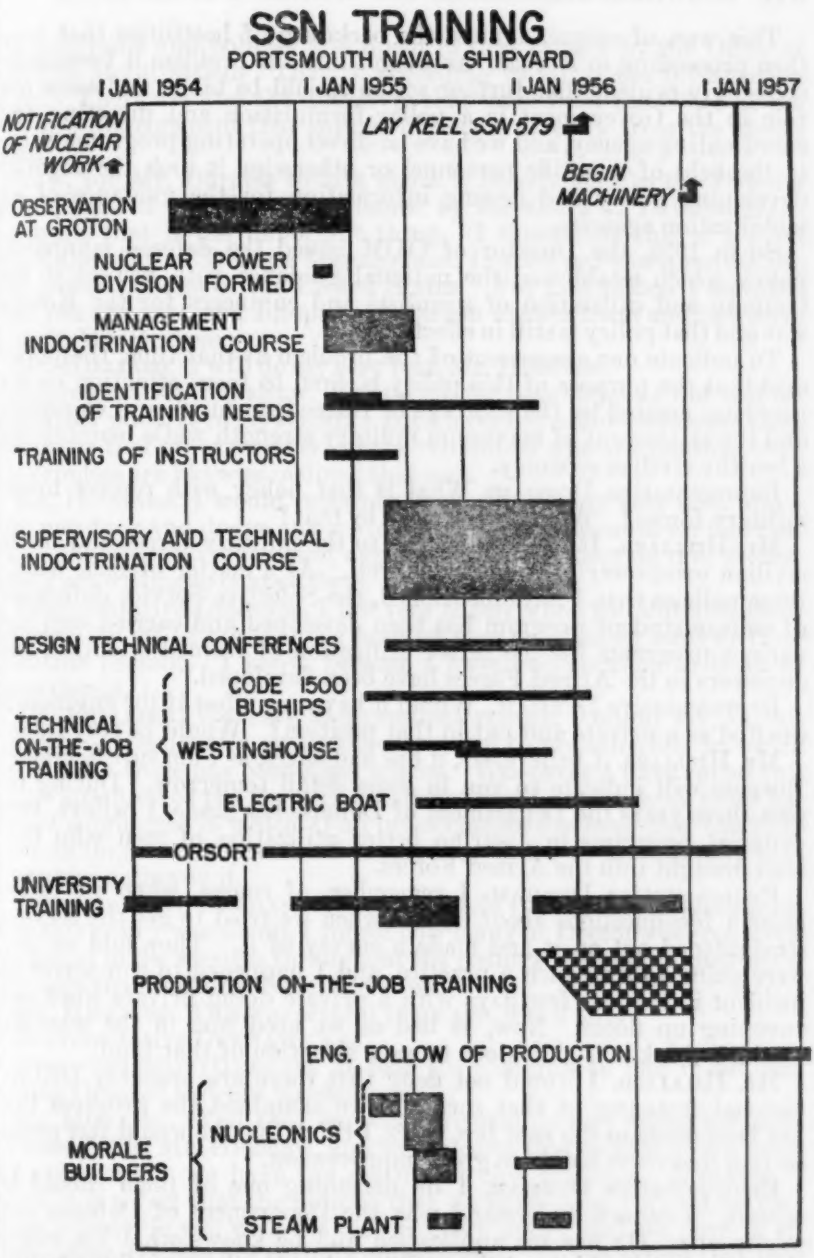
(See chart on opposite page)

Representative DURHAM. The next witness is Mr. John F. Hilliard, of the Office of Defense Mobilization.

STATEMENT OF JOHN F. HILLIARD, OF THE OFFICE OF DEFENSE MOBILIZATION

Mr. HILLIARD. Mr. Chairman, I would like to express the appreciation of the Office of Defense Mobilization for the opportunity to contribute our views to these hearings. I have had the opportunity to look over some of the statements that have been made by various experts in the past, today, and I would like to associate myself with them in their estimate of the extreme seriousness of this problem.

Since you have called a very distinguished group of individuals who are in position to talk on a great range of problems and possibly solutions in connection with the shortage of scientists and engineers, I would like to take just a few minutes and address myself to the specific role and responsibilities of the Office of Defense Mobilization, and to indicate very briefly what we believe the fundamental problems are that should be attacked and are being attacked, and then to attempt to answer any questions that you may want to ask me.



When the Office of Defense Mobilization was established in 1951, just a month after that the President announced at the recommendation of the Director of Defense Mobilization a national manpower mobilization policy, one part of which read as follows:

We must rely heavily upon science and technology. The most effective use must be made of our supply of individuals having the special skills required to develop and produce the necessary equipment and to use and maintain it in the Armed Forces.

This was, of course, against the backdrop of hostilities that were then proceeding in Korea. As we got into the problem it became increasingly evident that further action should be taken and since our role in the Government is a policy-formulation and directing and coordinating agency, and we have no direct operating programs either in the field of scientific personnel or otherwise, it took the form of developing policy and issuing information for the guidance of all mobilization agencies.

So in 1952, the Director of ODM issued the defense manpower policy which established the national guidance with respect to the training and utilization of scientists and engineers for the Korean war and that policy is still in effect.

To indicate our assessment of the problem at that time, the policy said that the purpose of this policy is, first, to focus attention on the problems created by the shortage of trained scientists and engineers, and the attainment of maximum military strength while maintaining a healthy civilian economy.

Representative DURHAM. What is that policy with respect to the military forces? What do you mean by that?

Mr. HILLIARD. It has application to the military forces and to the civilian manpower of industry as well. As a matter of fact, within these policies that I have mentioned, the Selective Service deferment of college student program has been developed and carried out, and various programs for the better utilization of trained scientists and engineers in the Armed Forces have been developed.

Representative DURHAM. Would it have any effect if the engineer is drafted as a private and put in that position? Would he stay there?

Mr. HILLIARD. I believe, sir, it has had effect, as I am sure Secretary Burgess will indicate to you in some detail tomorrow. During the past three years the Department of Defense has made, I believe, very material programs in assuring better utilization of men who have been brought into the Armed Forces.

Representative DURHAM. I remember, of course, when we raised quite a few questions about it, and when we tried to get the services straightened out on it and made a survey of it. They told us they were going to stop such a practice, and I happened to run across an incident in the last few days with a private doing private work and sweeping up floors. Now, as bad as we need him in the scientific world, I think it is ridiculous to see a situation of that kind.

Mr. HILLIARD. I would not deny that there are probably still occasional instances of that sort. If we examined the progress that has been made in the past few years, I think that we would feel pretty certain that there had been great improvement.

Representative DURHAM. I do not thing one of them should be missed. I cannot understand why the Department of Defense ever misses one. He has his application and he knows what his educational background is, and they still go ahead and assign them to that type of work.

Mr. HILLIARD. I would agree with you in principle, but I think Mr. Burgess may be in a position to answer that a little better than I can. He will be with you tomorrow morning.

Representative HINSHAW. If the gentleman will permit me, Mr. Burgess and the Defense Establishment are very largely guided by

the programs and policies laid down in that respect by the Office of Defense Mobilization. That is, according to all of the information I get. There are also the directives that issue from the Office of the Defense Management that supposedly come directly from the President.

Now, for Mr. Burgess to talk about it in reference to the Defense Establishment and the orders issued by the Office of Defense Management, that is the important thing. I think that this is a good place, the office of Defense Management, to start out and question the manpower policies of the United States. For that reason I am glad that you are here, and I hope that you can answer them and not leave it up to Mr. Burgess.

Mr. HILLIARD. I will do my very best, Mr. Hinshaw.

Representative HINSHAW. Excuse me for thus stepping out and being rather positive in my remarks, but I have felt so for quite some time. I am sure that other members of the committee who are familiar with the problem are likewise inclined that way.

Mr. HILLIARD. I would certainly be glad to do my very best, and I will not duck and dodge any more than I have to because we feel that these policies represent sound approaches, and if they do not, we certainly are willing to change them.

Representative DURHAM. I felt very happy when you initiated those policies, but still I say that the practice goes on of using some of these scientific persons. I know, because I have had occasion to learn of these things.

Mr. HILLIARD. We have had excellent results, I might say, in this respect. Occasionally an instance is called to my attention in which apparently there has been some miscue. Whenever I have called this to the attention of the Department of Defense I do not think there has been a single case in which, if an investigation disclosed that the facts were as they were represented to me, they failed to immediately take corrective action on it.

Representative DURHAM. When we made the first investigation before this policy was set up, I forget how many at Doctor's degree levels we found in the services throughout the country who were doing nothing more than washing dishes and so on.

Mr. HILLIARD. This was several years ago, was it not?

Representative DURHAM. Yes.

Representative HINSHAW. It took the Congress to find it out, and not the Office of Defense Management.

Mr. HILLIARD. Well, the Congress has certainly very potent influence in these fields, Mr. Hinshaw, and we welcome that as part of the overall opportunity we have for getting at this problem. However, I think it is a fact that the policies that we have—and I would be very glad to provide you with the text of every policy that we have in effect—these policies are entirely constructive. To the extent that they have not achieved the desired results, it reflects a problem of working out administrative systems in an extremely far-flung and complex military organization against a mission which has not been oriented altogether in the direction of scientific manpower.

Representative HINSHAW. May I ask a question there? Let me inquire concerning the so-called scientific and professional personnel

military occupational specialty, otherwise known as the M. O. S. of S. P. P. Now you and I both know that there are approximately 7,500 such persons with that M. O. S. in the Army alone. Goodness knows how many other persons are qualified for the M. O. S. but as there are only so many spots for that M. O. S., only so many are selected. I have no idea how many others who are entitled to that M. O. S. there are in the service who are not so designated.

Now these men who achieved the MOS of SPP are very, very highly qualified. They are engineering or scientific graduates with 3 years of experience, practical experience, in their field, or they are masters of science with 2 years' experience, or they are doctors of philosophy. They are not just ordinary graduates of a technical college. They have had experience or they have had educational qualifications which have carried them beyond the ordinary graduate. There is not the slightest doubt in my mind, and I do not know whether there is doubt in yours or not, but that it is as impossible to utilize that manpower successfully in the Armed Forces to the limit of their ability as privates first class.

Am I correct in that?

Mr. HILLIARD. Yes; that is correct. However, let me observe that the program to which you refer was put in to correct a problem that arose during Korea, in which many local boards and appeal boards felt that with the situation then prevailing they should induct certain men who had highly developed skills even though the general occupational justification may not have struck all of us as being entirely sound.

Once this program was put in, it began to weed this problem out on an individual and unit basis, I have recently visited down at the engineers school and find that there, to the best of my judgment and information, they have completely licked this problem. The S. P. P. people are being utilized at the kinds of skills they should be. I understand there are many installations in which this is the case. There are other instances in which the Office of the Secretary of Defense is constantly investigating and reviewing this situation with a view to bringing them all up to this level of performance.

Now, to further resolve the difficulty, the deferment policies of the Selective Service System in recognition of this growing problem are resulting in a very low intake of people having scientific skills and as a result of this we can foresee, if we have not already reached, the point in which there will be no men being brought into the Armed Forces by the draft who cannot be used effectively at the scientific and engineering skills they have acquired in their training. In short, it is a problem that will be phased out very rapidly within the next few months.

Representative DURHAM. I do not feel that we can fail at the present time to miss any of these malassigned—at the present time when they are interviewing boys leaving engineering schools at the 2-year level and they are trying to entice them to come to industry without going on to graduate.

Mr. HILLIARD. As a matter of principle, Mr. Durham, I could not disagree with your point of view at all. I agree that if we have one of the men having these skills who are being employed at military duties that bear no relationship to his qualifications that should be remedied.

Representative DURHAM. Especially in peacetime like this. In wartime it is different. I know we get some malassignments then but I do not think it should happen now.

Representative HINSHAW. Mr. Hilliard, I do not know what the situation is at Fort Belvoir at the moment. I have not been in contact with the people there since a bill which I have before the Armed Services Committee was being heard, I believe, last year, or last summer. But at that point this group of S. P. P. boys were organized into platoons and companies and whatever and I do not know whether they had a battalion of them down there or not, but naturally they were in the command of a duty sergeant who had no educational competence. He was a long-term career man in the Army and he knew his business so far as a duty sergeant's business was concerned. Apparently it was giving him a great deal of pleasure to assign these men to do the kitchen police work for the janitorial forces in Fort Belvoir. It was a sort of punishment to the people who thought he was a high-faluting guy because he had degrees in engineering and science.

Now, a fine piece of business that is. Of course that lowers the morale right away.

Then the business of doing guard duty in the place. They were once a week required to do guard duty. Now with all of these utilizations in addition to the engineering utilizations which they had, which were not necessarily according to their specialty at all, they could only get work out of them 4 days a week because the other 2 days were taken up with these two duties—one on kitchen police, and the other on guard duty.

Consequently, with the Sabbath off, I presume, it was 4 days a week utilization.

Now, they were supposed to work on certain projects. Right alongside of them stood similarly qualified personnel from the civil service of the United States in various professional grades drawing the salaries of the professional grades. I would like to ask you this, if you think that it is fair or right to extract from these men who are certainly competent and can give what they have, the kind of services that are being performed by men of the civil service P–1 and P–2 and P–3 grades, as private first class? If it were anybody else and if they were in under any other circumstances, they would immediately qualify when they went onto that work as master engineers at a minimum. They could qualify as first and second lieutenants, and some of them captains in the Corps of Engineers. They certainly are as well qualified educationally as an officer of the Corps of Engineers, and I say that as an ex-officer of the Corps of Engineers of the United States Army—the Regular Army at that.

I think that I know what I am talking about.

Mr. HILLIARD. Again, Mr. Hinshaw, I think that I should say that I do not feel that it is my responsibility, and I am not really qualified to defend the administrative practices in this program carried on by the Department of Defense. But I would like to make these observations: I just heard Admiral Rickover testify that the greatest loss that they have of people in the enlisted grades in these programs is the commissioning of them as officers. The same situation seems to prevail at Belvoir, and I understand at other bases.

Representative HINSHAW. Pardon me just a moment. Now, these are draftees.

Mr. HILLIARD. That is right.

Representative HINSHAW. And draftees are not permitted to go to Officers Candidate School.

Mr. HILLIARD. That is not my understanding of it.

Representative HINSHAW. Unless they enlist for the full 4-year term.

Mr. HILLARD. I was just going to say that.

Representative HINSHAW. Why should a doctor of philosophy enlist for 4 years in the United States Army, to become a second lieutenant?

Mr. HILLIARD. Well, the only point I am attempting to make—and I agree with you when you have 2 men working side by side and 1 making 4 or 5 times as much as the other you automatically have a morale problem—is that these people are frequently offered opportunities to qualify for commissions, and many of them refuse this because this would perhaps lengthen their term of service by a year or more. Others feel that they can assume less responsibility and they just do not elect for one reason or another to improve their situation.

On the other hand, as I indicated before, the information I have gotten from Defense, indicates this is a situation which in the past has admittedly been far different than it is now. But it is phasing itself out because of the new programs we have, because of the draft situation, and other actions being taken in the Department of Defense.

I would like to reiterate that the policies which the Director of Defense Mobilization has issued never have provided for a situation of this sort nor do we condone malutilization wherever it may take place.

Representative HINSHAW. May I suggest this, that if the policy of the Director of Defense Management in the Office of Defense Management were such that it would be a direct violation of the policy to allow any such situation to exist, that is to say, malassignment or malgrading or whatever, or maluse, or even to take into the military service at all such personnel, why of course it would not be done.

Now, I would like to draw a picture for you. I presume you have considered it and others have considered it, but I would like to draw a picture for you of the young man who is qualified for and who is taking on as best he may an engineering or scientific education. I have had some experience with that, too.

He graduates from prep school or high school or wherever, and he is well qualified mentally. Then comes to him immediately the first question: "Shall I enlist now and do 2 years of service or shall I wait?" He says, "Well, I am admitted to this college," because he is well qualified, and he is admitted to the college without examination or with perfunctory examination. So he decides to take that while he is qualified for it and he continues his studies.

So he goes into college. There he has the opportunity to join the ROTC and he is given a chance to become a junior ROTC and later a senior ROTC. If he takes the senior ROTC course, then immediately upon graduation he is subject to 2 years of duty and 8 years in the Reserves and so he must break off at the time of graduation and do his 2 years of duty. But he wants to go on and take a master's degree or possibly a doctor's degree and so he does not join the senior ROTC,

with his colleagues. At the graduation, he graduating high in his class, perhaps phi beta kappa, or so on, he goes on for his graduate degree. He is automatically deferred by his high standing and his acceptance in the graduate school.

But some period down the line he knows that ultimately he is going to have to take 2 years' service. At what time is he going to do it? He comes along and he goes through his doctor's degree and under the Reserve Act recently passed last year by the Congress and now law, he can go on through to the doctor's degree and then he must do 6 month's service and take the balance of it in some kind of a Reserve organization into the far distance of time. I forget the terms that are used, but there is a reserve and a subreserve behind that into which he can be thrown. That is, providing, of course, he accepts employment in a suitable place.

Now, nobody objects particularly to that course of action. That has eased up the problem a great deal for the boy that is presently in school, that is, except for the decision that he has to make upon graduation or really upon going into his third year which means the senior ROTC. But for those boys who have been through it before the passage of this act and are now in the SPP, there is no opportunity for them but to go on and serve out their time in the reserves and there are, as I say, 7,500 of them, or about that. Is there any reason why those people who are in the SPP program at the present time should not be given the same opportunities and privileges as those who have come after them.

Mr. HILLIARD. Well, we have discussed this and certainly Mr. Burgess will present you with his point of view.

Representative HINSHAW. I have his views of it in a letter from him. I am asking you.

Mr. HILLIARD. Our own view is that the problem in terms of their utilization has already been reduced to small proportions. And since the act was passed nearly a year ago there could not be any man under the draft who has more than about a year of service left.

In addition to that, when you go back and make these things applicable to men who have been already assigned in the service, some of them perhaps in an overseas assignment, I can see how this would pose extremely difficult administrative and morale problems for the Department of Defense. At the same time, I might say, Mr. Hinshaw, that we have studied your views and the bill which you prepared, and I can say in all candor that we feel that this is an important point of view. We studied it very carefully and discussed it at very great length with representatives of the scientific community, with industry and with labor and all of the groups that are advisory to us. After this kind of consideration it was our judgment that the kind of bill which the President submitted was preferable for many reasons.

At the same time, I want to make it clear that we do not feel that there is a single and only right way to deal with this problem. We feel that the system that has been developed is a good system, and given the kind of support we think we are getting for it it will do the job you have in mind.

Representative HINSHAW. May I ask you this: Does the man who takes the senior ROTC course and does graduate as a second lieutenant have the same opportunities of 6 months' service and going into the distant Reserves as the enlisted man?

Mr. HILLIARD. If he is not needed. He is not under the same law, but if he is needed for only 6 months, he takes the minimum of 6 months and he goes into the Reserves. If he is needed on active duty for a longer period of time he will be kept for 2 years.

Representative HINSHAW. Who decides that?

Mr. HILLIARD. The service into which he is commissioned.

Representative HINSHAW. That is the whole thing. There is no policy on the subject from the Office of Defense Management. If there was policy on it, they would be automatically sent into the Reserves if they were needed in industry and there was a shortage; and there is a shortage in industry and they are needed.

Mr. HILLIARD. Even if they are needed in the active forces, too.

Representative HINSHAW. Of course. They cannot be necessarily needed in the active forces as engineers and scientists because they come out with no experience.

Mr. HILLIARD. I think that there is something to be said for the fact that many men are getting commissioned in a service and branch which has little need for them in an assignment related to their civilian training. Let me call attention to this: All of the participants in the ROTC program are people who voluntarily and on their own volition enter into this program. I am not quite certain that we would want to draw such a fine line limiting the opportunity for these young men to decide about their military service as long as they understand what the facts are.

Representative HINSHAW. Let me point something out to you. Every man that I am talking about is equally qualified mentally. He is equally qualified for a commission, but in order to obtain the 6-month assignment for sure, and then go into the reserves, he has to be an enlisted man. As an officer then he is subject to any call that the military wants.

The highest duty in the military, as you know, is as a platoon leader. I think that that category should be changed also, and the highest duty that they can perform in the military might be as a scientific and professional officer.

Mr. HILLIARD. I am not sure that I understand your point. However, in terms of the young man's career development, I think the fact that he has acquired his commission and performed as an officer for a period of time, may be regarded as a real asset to him. I personally think it is an asset to him no matter if he does go into technical pursuits as his primary occupation.

Representative HINSHAW. But you see, there is the requirement that if he is to go on and take a master's degree and a doctor's degree, he must take the hiatus of 2 years of service right then upon his graduation, that is, if the becomes an officer. If he wants to continue on to his doctor's degree, as a continuous performance, he has to become an enlisted man at the end of his time because he is in a draft status. He can enlist for 4 or 6 years, and who wants to do that at that point when you are a doctor of philosophy or a master of science?

Mr. HILLIARD. I do not think that this is necessarily the only alternative open. For example, there are many men now who went on to take graduate work and to complete their terminal degrees who still have a military liability and will until age 35 but who are now in very low draft priority and except in a time of national emergency

would not be subject to call and would be eligible for deferment on other grounds.

I think that the situation which you describe is theoretically possible but as a practical matter it is not the way that the thing works out.

Representative HINSHAW. It is not the only way, but as a practical matter it works out that way in a majority of the cases. I myself, as I say, am an ex-soldier and most of the people here on this committee are ex- one thing or another.

Mr. HILLIARD. I might say that I am, too.

Representative HINSHAW. I understand so, and we appreciate those things, but we also appreciate the fact that in some countries which have a high regard for the things that the engineer and the scientist can do for the military, these men are completely assigned to their duties as scientists and engineers and are completely deferred from military service as such.

Mr. HILLIARD. I agree, and yet I would like to say that this is a hard choice to make. One of the grounds of our thinking was the point that Dr. Kelly made yesterday—that in the United States even with the problems which you described the scientists and engineers and their organizations have felt that they did not want to be made into an elite corps and provided some special exempt status. I have great admiration for the fact that they do not want to take on some status that would gradually make them suspect by the other people who do not have it.

Representative HINSHAW. They do not want to ask for it, and rightly so, and you would not ask for it if you were the head of such a society either. But you and I as employers, will be very anxious to have that take effect right now so that we could have 7,500 more, and goodness knows how many in addition to that, to make up for some of the shortage that we are talking about.

Mr. HILLIARD. Mr. Hinshaw, we have had two men who have made very outstanding careers for themselves in industry for 6 months, tours as Assistant Directors for Manpower in the Office of Defense Mobilization. And I do not believe that either of them as employers would propose that an exemption program for scientists and engineers be adopted even though they realize that it might give them a little greater claim on the numbers available.

Representative HINSHAW. What are we talking about then, and why complain about the shortage of engineers and scientists? No one is complaining and so let us have the shortage and let us continue to be behind on the work that we are doing and let it all go. If that is the way to do it, we can do that.

Mr. HILLIARD. The problem, as I see it, sir, is this: That in any difficult problem there is seldom a clear-cut and one-shot answer.

Representative HINSHAW. Let us say these people are not coming in and asking for it but you and I as Government people, it is our duty to go find these people, to be employed in these undertakings which we, ourselves, are encouraging the manufacturers and the engineering companies and the universities and whatnot to do. Now they are talking about shortage, and say, "we do not want to ask for anything." All right, "we will give it to you." Is that not the proper answer?

Mr. HILLIARD. That may be. I do not know. But the fact still remains that many of the unhappiest scientists and engineers that

I ever met were people who felt that they were somehow or other working themselves into a position that would gradually react against them because of the fact that they were not taking their military service along with other people. I have known some of them who have voluntarily gotten themseves into the most ridiculuos positions in terms of their utilization because they have gone down and volunteered for some military program which did not even remotely promise to use them in the fields in which they were highly trained. So what we have worked for, and I think with a reasonable degree of success, is a series of alternatives under this new Reserve Act whereby men would have at least the opportunity to make intelligent choices.

Representative HINSHAW. We have placed at the pinnacle the man who carries a gun and placed at the base of the pyramid the man who has the brains to develop an atomic weapon, let us say.

Mr. HILLIARD. I am afraid that I could not subscribe to that.

Representative HINSHAW. I would like to know what else it is, because all of them have an inferiority complex if they have not served carrying a rifle.

Mr. HILLIARD. Well, for example, this new program which was enacted last fall allowing men who have special skills including highly developed manual skills, to take a tour of active duty for training for 6 months and then go into a Reserve component.

Representative HINSHAW. As an enlisted man?

Mr. HILLIARD. Yes. There is not anything that I can think of that is degrading about serving as an enlisted man.

Representative HINSHAW. There is nothing degrading about it except he is more competent to do some other thing for that 6 months than he is for the thing he is being assigned to and it is 6 months that is completely lost and the brain power is completely lost for that 6 months and there is a hiatus in the use of that brain power which requires a certain period of retraining afterward in order to reestablish.

Mr. HILLIARD. Yes, I agree that this is true, and the question is, when we do reach a point at which the Congress and the executive branch and most important of all the individual are all capable of adjusting our thinking to a series of values different from those on which we are operating at the present time. In terms of theoretical perfection of performance, I could not quarrel with you.

Representative HINSHAW. Let me give you a ridiculous and an absurd case. There is always an ultimate case. But here is a man in an atomic-energy project, a personal friend of mine. He is the medical officer whose duty it is to see to it that the rest of the people in the project do not become subjected to radiation doses, and if they do become subjected to radiation doses then he is the one man on that project who is qualified to do whatever can be done and there are a number of things that can be done to prevent damage to the personnel. He is probably the most highly qualified in the whole medical profession in that particular subject.

Yet his draft board has classified him as 1–A, at the age of 26, and he must go and serve.

Now, he either has to serve as an enlisted man for 6 months or as a physician he must be drafted by the physicians' board as a physician in the Armed Forces. Then he has got 2 years of service to perform.

Now, it is proposed that they put him into uniform a few days and

make him a major or whatever it is in the Medical Corps, and assign him directly back to the thing that he is now working for as a major in the Medical Corps. How ridiculous can you get? He would take off his uniform and become major and go back on the same detail.

Mr. HILLIARD. It so happens that we have every once in a while a case of that sort. As a matter of fact, a year ago we had an almost identical case, but these are rare in individuals that you are describing. In every instance where a case of this sort is brought to our attention we bring together the people who know all of the facts and the people who are in a position to exercise first-class professional judgment on the matter. We have not only a Health Resources Advisory Committee in the Office of Defense Mobilization, but a Science Advisory Committee, both of them made up of nationally known authorities in those fields.

We ask them to give us a judgment as to the issues that are involved. I can say without prejudice to the case that you cite, that in every instance where we have made a special effort to consider the facts, we have found there were circumstances in which it was the judgment of the professional people in the fields represented that the board was acting for one reason or a combination of reasons in the right manner.

Now there have been a few instances I have known in which there was a contrary situation and I have discussed this at length with the Presidential Appeal Board of the Selective Service System. I have enjoyed the finest kind of collaboration with them in matters of this sort. They are constantly handing down appeals in cases of this kind, and there is not a possibility of a case like this getting finally adjudicated without a group like that having a look at it. I personally have great confidence in the judgment and sincerity of the Presidential Appeal Board.

Representative HINSHAW. And undoubtedly there will be unfavorable decisions and those unfavorable decisions will arise, I think, very largely on account of the policies that have been established by the Office of Defense Management.

Mr. HILLIARD. To maintain that there have been no imperfections in our policy, of course, would be ridiculous and impertinent on my part, Mr. Hinshaw. I would not even attempt to say that. But I will say this, that we have modified these policies in many particulars over the past 5 years and wherever we have had brought to our attention a situation which is in fact a policy problem we have modified those policies.

Now within the policy framework, the administrative execution of these policies is also a great problem. The people who carry them out have more difficulty than we do in developing them because this goes right out to the final man in Korea or in Germany or in any of many nations of the world. These policies have to be applicable to all of those things against a background of military considerations; problems of rotation, morale, and all sorts of things.

So if there have been difficulties, I think Secretary Burgess not only has been extremely alert to this problem and has done a great deal to resolve it, but will welcome specific suggestions at any time as to how his administration of these policies might be more effective.

Having said that, I do not contend that errors have not been made and perhaps will continue to be made, but I think on a progressively less frequent basis.

Representative HINSHAW. Let me ask you a question there, Mr. Hilliard. Why is the word of the contractor and the manager in a case of an atomic energy project not taken as to the need of the services of the particular man in that field and why is it left up to maybe some board of fine farmers, high-spirited farmers, who know nothing about the atomic energy project?

Mr. HILLIARD. Because, I think, it is the law of the land.

Representative HINSHAW. Because they recommended the law of the land be that way. I was present when you people, I think it was General Hershey, in conjunction with the Office of Defense Management, recommended that there be no special favors offered to people on projects in the national defense. He said that he could do it administratively and let it go at that.

Mr. HILLIARD. There were many features in the law that did provide for these. I happened to be out of the country when these hearing were going on last spring, but I have read the testimony and I know what was said. I participated in the development of this legislation. I can point out at least 3 or 4 basic features that had to do with special treatment of men having these skills.

Representative HINSHAW. I asked a specific question just now, why the word was not taken of these men who were the contractors to the Government and the Government managers of the projects?

Mr. HILLIARD. There are many reasons, but one is this——

Representative HINSHAW. Are they not competent to say?

Mr. HILLIARD. They are competent, but in very frequent cases they do not exercise their competency in this field.

Representative HINSHAW. Why do they not exercise their competency just the same as you people or the Selective Service people exercise their competency?

Mr. HILLIARD. I have had occasion to look at instances in which an employer in the nuclear program made claim for deferment of a large number of young scientists and engineers. In making that claim, the form on which he filled out his claim for their deferment had been mimeographed and only the name had been typed in. Now, since the law contemplates that deferment is an individual matter, it would seem to me that something more than this would be necessary to demonstrate the individual's necessity in the national interest in that employment. In many instances, the local boards and the appeal boards have almost been compelled to make the case for themselves for the deferment of the individual since his employer did not take adequate pains to do it.

Now, I make this statement not as criticism, because the people who are engaged in these programs have many important things to do. But in simple compliance with the legislation, which, incidentally, I think is quite sound on this point, if the employer does not take the trouble to show why that individual is important in the national interest in his employment, it seems to me that he has not done his full job as an employer.

Representative HINSHAW. I have been getting the same kind of answers out of gentlemen in positions that you have referred to for a matter of 3 years and the condition is improving somewhat, thank goodness, but I expect to continue to elicit answers and pound on the question until it is down to the point that I think it should be, and

that is where the men who have the brains to produce the things which can save thousands of lives are permitted to use their brains without going through a lot of rigmarole and dodging the draft. That is where they will be given a position of honor in the eyes of the public and not one of having escaped services of some kind because they have produced these great instruments like the radar, and like the other electronic devices which are so necessary to the operation of planes and guided missiles and even atomic weapons today. It is ridiculous. They have performed equally well, certainly, when they produce these fine things to be used by our military forces. I think that they are worthy of high honor, and not have to be subjected to such debasing criticism that comes to them for not having carried a gun for 6 months or so.

Representative PRICE. Would you proceed with your statement, Mr. Hilliard.

Mr. HILLIARD. Mr. Chairman, I do have perhaps a 10- or 15-minute statement, but if your time is running out I would be glad to slightly modify this and give it for the record rather than to take up an undue amount of time.

Representative PRICE. I suggest that you submit the full statement for the record, and without objection it will be included in the record.

(The statement referred to follows:)

STATEMENT OF JOHN F. HILLIARD, DEPUTY ASSISTANT DIRECTOR FOR MANPOWER, OFFICE OF DEFENSE MOBILIZATION, EXECUTIVE OFFICE OF THE PRESIDENT

Mr. Chairman, I appreciate the invitation of this subcommittee to present the views of the Office of Defense Mobilization with regard to the shortage of scientists and engineers. We believe that these hearings can serve a valuable purpose in dramatizing to the American people the importance of our scientists and engineers to Nation's security and its economic growth.

The subcommittee has secured a considerable number of outstanding witnesses who are well qualified to speak on the various aspects of this manpower shortage, and on the measures which are being taken and which should be taken to deal with it. I shall therefore confine my remarks to a brief evaluation of the problem from the standpoint of the Office of Defense Mobilization.

As you know, the Office of Defense Mobilization has the responsibility for coordinating and directing activities in the mobilization field. The Director of ODM is further charged with advising the President on all aspects of mobilization. These responsibilities, of course, include policies and programs for the development and utilization of manpower for national security purposes.

From the beginning of ODM we have regarded the training and effective utilization of scientists and engineers as fundamental to our national security. On January 17, 1951, just 1 month and 2 days after ODM was established, the President, on advice of the Director of Defense Mobilization, issued the national manpower mobilization policy which in part said:

"We must rely heavily on science and technology. The most effective use must be made of our supply of individuals having the special skills required to develop and produce the necessary equipment and to use and maintain it in the Armed Forces."

This policy then spelled out the fundamental steps to be taken to achieve this objective. One of the more important of these steps was the student deferment program, which has been of tremendous value during the past 5 years in continuing the flow of young scientists and engineers from our colleges and universities.

On April 20, 1951, the Director of ODM established the ODM Committee on Specialized Personnel to advise on mobilization of scientists and engineers and other professional manpower. This committee, composed of outstanding representatives of the scientific community, education, management, labor and Government, has been consulted on every manpower action by ODM relating to scientists and engineers during the past 5 years.

On September 6, 1952, the Director of ODM issued Defense Manpower Policy No. 8 establishing our national policy with regard to the training and utilization of scientists and engineers. It said in part:

"The purpose of this statement is: (1) To focus attention on the problems created by the shortage of trained scientists and engineers in the attainment of maximum military strength while maintaining a healthy civilian economy; (2) to indicate actions which should be taken to provide scientific and engineering manpower to achieve necessary research and development and production goals for 1952 and for the years immediately ahead; (3) to provide an initial program to meet scientific and technical manpower requirements for a broadened mobilization base."

The policy then stated explicitly the actions to be taken by the various departments and agencies to achieve its objectives. It further indicated the major measures which should be taken by management, professional associations, and educational institutions to help alleviate the shortage of scientists and engineers.

In August 1953, the Director of ODM established the Committee on Manpower Resources for National Security. On December 18, 1953, that Committee reported to the Director of ODM on overall manpower resources for national security and observed:

"In the event of an emergency, our resources of highly trained manpower will probably be the ultimate limiting factor in our capacity for mobilization."

Three weeks later, the Director of ODM recommended to the President a sweeping revision and strengthening of military Reserve program with one of the major objectives the securing of efficient allocation and utilization of scientific manpower in time of emergency. As a result, the President directed the development of a new military reserve program. The national Reserve plan was developed by the executive branch in 1954 and enacted by the Congress in 1955. This plan is geared to the basic needs of both military and industrial mobilization.

Provisions for the training and balanced distribution of men with key military and civilian skills are now basic features of the military Reserve program. The short-term active duty for training of men under 18½ years of age will help augment the Ready Reserve forces with the least necessary disruption of civilian training or employment. The special provision for the short-term enlistment of men having certain critical civilian skills helps meet the manpower requirements of important defense production and of defense related research and development. The continuous screening of the Ready Reserve assures a balance of military skills in the Active Reserve forces without a waste of civilian skills more needed in defense-supporting activities. The selective recall of members of the Standby Reserve provides for the measuring of military requirements against defense-supporting requirements for all reservists except those in the Ready Reserve.

In 1955, a special Cabinet-level committee headed by the Director of ODM reported to the President that there is a shortage of highly qualified scientists to meet our present and future national security needs, and recommended that action be taken to mobilize and coordinate both private and governmental resources to solve the problem.

In response to this recommendation, on April 3, 1956, the President established the National Committee for the Development of Scientists and Engineers. I would like, Mr. Chairman, to introduce into the record the membership of this distinguished committee.

MEMBERS OF THE NATIONAL COMMITTEE FOR THE DEVELOPMENT OF SCIENTISTS AND ENGINEERS

Dr. Howard L. Bevis, president, Ohio State University, Chairman
Dr. Eric A. Walker, dean of the Pennsylvania State University Engineering and Architectural College, Vice Chairman

Engineering

Mr. Thomas H. Chilton, president, Engineers Joint Council
Dr. Maynard M. Boring, president, American Society for Engineering Education

Science

Dr. Detlev W. Bronk, president, National Academy of Sciences
Dr. Paul B. Sears, president, American Association for the Advancement of Science

Education

Dr. Arthur S. Adams, president, American Council on Education
Dr. Irvin Stewart, president, American Association of Land Grant Colleges and State Universities
Dr. J. Lester Buford, president, National Education Association
Dr. Robert Stollberg, president, National Science Teachers Association
Dr. Leland N. Drake, president, National Association of Secondary School Principals

Management

Mr. Cola G. Parker, president, National Association of Manufacturers
Mr. A. Boyd Campbell, president, United States Chamber of Commerce

Labor

Mr. George Meany, president, American Federation of Labor—Congress of Industrial Organizations

State and local governments

Hon. Arthur B. Langlie, Governor of the State of Washington, chairman of the Governors' Conference Council of State Governments
Hon. John B. Hynes, Mayor of Boston, Mass., president of the United States Conference of Mayors
Dr. Edgar Fuller, executive secretary, Council of Chief State School Officers

Humanities

Dr. Fred Eggan, chairman of the board, Social Science Research Council
Dr. Howard M. Jones, chairman, American Council of Learned Societies

In his letter appointing Dr. Howard L. Bevis, president of Ohio State University, Chairman of the Committee, the President said:

"For the last several years there has been a growing awareness within the Government and among private citizens in general that as a result of our continuing shortages of highly qualified scientists and engineers we are running the danger of losing the position of technological preeminence we have long held in the world."

In announcing the Committee, the President said:

"Our technological superiority is now seriously challenged by those who use science for aggression and conquest."

I do not mean to suggest that the actions taken by the Office of Defense Mobilization thus far are by any means adequate to solve the problem of a shortage of scientists and engineers. I indicate these action only to emphasize our profound concern about the relationship of this shortage to our national security. Much more must be done. One of the most important, of course, is the alerting of the American people to the problem and to their responsibility for helping to work out solutions to it.

A great deal has been said in recent months about the progress of the Soviet Union in the fields of technology and in the training of scientists and engineers. There is no doubt that this progress, especially in the weapons field, must be viewed with sober concern by the free world. However, the proper response to this challenge is one of courageous and effective action rather than of hesitancy and apprehension.

To bring the manpower equation into as sharp focus as possible, I would like to present a few statistics which are the latest and best figures we have on the United States-United Soviet Socialist Republics scientific manpower comparisons. First, however, it should be said that these figures, although we believe them to reflect the general situation correctly, no doubt contain some appreciable degree of error.

STATISTICAL DATA ON SOVIET SCIENTIFIC MANPOWER

I. The relative sizes of the major groups in scientific manpower as of mid-1955

	U. S. S. R.	United States
Living graduates (all fields)	2,900,000	6,275,000
Living graduates (scientific fields)	1,570,000	1,895,000
Graduates employed (scientific fields)	1,250,000	1,185,000
Scientists in research and teaching	175,000	265,000
Holders of kandidat degree (U. S. S. R.) and doctor of philosophy and doctor of science (United States) in scientific fields	72,000	55,000

II. Number of graduates per year in the major scientific fields

[Thousands]

	Physical sciences and engineering		Agricultural sciences		Health sciences		Total	
	U.S.S.R.	U. S.	U.S.S.R.	U. S.	U.S.S.R.	U. S.	U.S.S.R.	U. S.
1954	68.4	37.0	21.0	14.1	25.3	26.6	114.7	77.7
1955	79.3	37.7	24.2	13.3	26.4	26.1	129.9	77.1

NOTE.—Date of information, mid-1955.

III. Number of persons holding higher degrees (as of mid-1955)

[Thousands]

	U. S. S. R. (Kandidats)	United States (Ph. D's and D. Sc.'s)
All fields	83	108
Scientific fields	72	55
In physical sciences and engineering	37	34
In agricultural sciences	14	12
In health sciences	21	9

IV. Higher degrees in science awarded annually (as of mid-1955)

[Thousands]

	U. S. S. R. (Kandidats)	United States (Ph. D's and D. Sc.'s)
1952	5.95	
1953	7.25	
1954	8.00	
1955	8.65	4.24

V. Number of scientists in research and teaching (as of mid-1955)

[Thousands]

	U. S. S. R.	United States
1955	175	258

Even if we discount the accuracy of these statistics it seems possible to reach only one reasonable conclusion: The Soviets today have a technological labor force roughly the size of our own, and if the present trend is continued, it will exceed ours in the years immediately ahead.

An important question which deserves an answer is, "How good are the Soviet scientists? How do they compare with those of the United States?" This is a very difficult question to answer, since qualitative aspects of manpower are even harder to assess than numbers. In general, we are compelled to believe, on the basis of scientific and engineering achievements in Russia and on the limited contact our scientists have had with Soviet scientists, that the qualifications of their abler men are comparable to those of our own. Certainly, we are no longer justified in assuming that the Soviet technological labor force is made up of large numbers but poorly qualified scientists and engineers.

In order to deal effectively with the problem of maintaining a rate of technological development adequate for our national security, we believe there are three major action programs which are of overriding importance.

1. Effective efforts should be made by business, Government, and education to utilize more effectively those who have been trained as scientists and engineers

The years which lie immediately ahead may constitute our most important years in terms of maintaining technological superiority for the free world. Unless the short-run problem in the decisive period which we are approaching is successfully solved, there may be no long run.

We are giving attention as never before to what needs to be done in our secondary schools and in our institutions of higher education in order to improve the training of future scientists and engineers. This is all to the good. However, we must not let this concern with our educational programs distract our attention from the problem most immediately at hand. If we fail to achieve our technological potential in the next few years, we may gravely jeopardize our national security before their is opportunity to effect the educational improvements which we all agree should be made.

2. We should develop programs which will enable the scientists and engineers of the free world to work together more effectively

During the past decade there has been tremendous progress in the direction of effective collaboration on the part of the nations of the free world in both the military and economic areas. We have learned that pooling our thinking and our resources strengthens all who participate in such programs.

In the scientific area, the nations of the free world have not made as marked progress in working together as we have in these other two areas. Recently, however, there has been a noticeable trend in the direction of collaboration. This trend should be accelerated. More effective collaboration in scientific activities is one of the most essential measures for maintaining the technological superiority of the free world.

3. Our educational system should provide us with more and better trained scientists and engineers

Others whom the subcommitte has asked to appear can speak with more authority than I upon the specific measures for improving our educational programs at all levels. However, our own studies have made it clear that if our trained manpower resources are to keep pace with our requirements, broad, effective, and sustained programs must be undertaken in the following areas:

(*a*) Motivation of students at all levels.

(*b*) Identification and guidance of students gifted in scientific studies.

(*c*) Improved instruction at all levels.

(*d*) Greater opportunities for able young people to take highest level training of which they are capable.

(*e*) Increased recognition of scientists and engineers for outstanding achievement.

These are the areas in which the Government is attempting in every appropriate way to make its contribution to a solution to the problem more effective. These are the areas in which, I believe, the National Committee for the Development of Scientists and Engineers will concentrate much of its effort.

In conclusion, I would like to say that our emphasis on science and engineering does not mean that we are unmindful of the fact that our national security is built on values far broader than science and technology. As the President said in establishing the National Committee for the Development of Scientists and Engineers:

"World technological leadership carries the inherent responsibility before the world of using technology to help all peoples achieve a better life through the development of their resources for the good of all mankind. How we do this will require the most intensive effort in all fields of learning. We must nourish those basic roots of our traditions and culture which lie deep in the humanities and the social sciences, and in our fundamental religious conception of the relation of man to his Maker."

We believe this concept provides the most reliable guide to action in meeting the problem being studied by this subcommittee. We believe it is the fundamental way to achieve national security.

Representative PRICE. Now, are there any other things that you want to highlight here this afternoon or any recommendations you might want to make?

Mr. HILLIARD. I would like to get down to what we regard as the three overriding matters that require attention at this time and for the period ahead, to deal with this problem.

First, we feel that specific and effective efforts should be made by business, Government, and education to utilize more effectively those who have been trained as scientists and engineers. It is conceivable that the years which lie immediately ahead may constitute our most important years in terms of maintaining the technological superiority of the free world. Unless the short-run problem in the decisive period which we are approaching is successfully solved, there may be no long-run.

We are focusing our attention as never before on what needs to be done in our secondary schools and in our institutions of higher education in order to improve the training of future scientists and engineers. This is all to the good. If we are not careful, however, it can become a device for distracting our attention from the problem most immediately at hand. If we fail to measure up to our technological potential in the next few years, it will be because of our failure to utilize effectively those who already have been trained as scientists and engineers.

In other words, Mr. Chairman, it is our feeling that as important as the educational achievements and advancements are that have been spoken about and which others will indicate, we have today, we believe, the greatest technological manpower force on earth and we are not going to add to that very substantially short of 5 to 10 years, no matter how much we step up our training. Consequently, at least in the short-run, our problem must be solved with the manpower we now have and I think that is a point that we should never overlook when we start talking about vast programs of improvement in the schools. I do not say that to in any way diminish the importance of the educational problem.

Second, we feel that in order to extend the resources of technological manpower that we have we must develop programs which will enable the scientists and engineers of the free would to work together more effectively. This is another means by which we can greatly extend in the near term, our technological potential. The past decade has been characterized by tremendous progress in the direction of effective collaboration on the part of the nations of the free world in both the military and economic areas. We have learned that pooling our thinking and our resources strengthen all who participate in such a program. In the scientific area, however, the nations of the free world have not made as marked progress in working together as we have in these two other areas. Recently, however, there has been a noticeable trend in the direction of collaboration. This trend should and must be accelerated. If it is not, we will be losing some opportunity to do more than we are doing to maintain the technological superiority of the free world.

Third, of course, it is to emphasize what has already been emphasized that our educational system should provide us with more and better trained scientists and engineers. I will not speak to that beyond saying that we associate ourselves with the other representatives who have spoken about it. I would only like to say in further observation that it has now become clear that the Soviets are roughly comparable to us in terms of the numbers of their trained scientists and engineers,

and they are now training, as you know, a somewhat larger number than we are; this poses a real problem to us not only in terms of our national security from a military standpoint, but as the time goes on we feel that the advances in science and technology as reflected in a trend toward economic imperialism on the part of the Soviet Union poses a growing threat to our national security as well.

In conclusion, we believe that these threats can be effectively countered only by, first, more effective utilization of the scientists and engineers we now have; secondly, training of more an better qualified scientists and engineers in the years ahead; and third, more effective collaboration with the scientists and engineers of the nations of the free world.

In making these observations I would like, however, to point out that we are in no sense assuming that technological supremacy is the only avenue toward national security. Our emphasis on science and engineering does not mean that we are unmindful of the fact that our national security is on values far broader than science and technology. The President expressed this thought very well when, it establishing the National Committee for the Development of Scientists and Engineers, he said this:

> World technological leadership carries the inherent responsibility before the world of using technology to help all people achieve a better life through the development of their resources for the good of all mankind. How to do this will require the most intensive effort in all fields of learning. We must nourish those basic roots of our traditions and culture which lie deep in the humanities and in the social sciences and in our fundamental religious conception of the relation of man to his Maker.

Representative DURHAM. Why do you say that there is no possible way, as I understood your statement, to make any increase in the scientific personnel in the next 5 years? Our colleges and our universities and our grade level and high school level institutions are at the highest enrollment in the history of our country. There must be some cause for that.

Mr. HILLIARD. I did not say quite that, Mr. Durham. I said that in terms of great or dramatic increases that would be true. We have about 650,000 engineers, and about 250,000 scientists. Even though the number of engineers and scientists we are training is going up, we have a loss from our scientific and engineering labor force each year through death, retirement or transfer to other fields of endeavor. So even though we trained, for example, this year, 29,000 engineers, and perhaps 4,500 scientists at the Ph. D. level, the net increment to the technological labor force would be substantially less than those numbers would indicate.

So if you multiply by 5 or 10 years the net increment to our scientific labor force of those coming out of our colleges and universities, the net addition as against our total would be a relatively small percentage. That is what I am trying to say.

Representative DURHAM. Well, according to the figures and estimates that have been given us, Russia did this thing in approximately 15 years to where, beginning at the ground level almost, you might say, they did a wonderful job. That is, according to the figures we have, it is amazing. Now, if we are potentially ahead of them in everything else, I cannot understand why we are not potentially ahead of them in turning out personnel that is qualified to do technical work.

Mr. HILLIARD. There are a number of reasons for that, I think. I do not mean to imply that we are necessarily behind them. The program which they started was begun about 30 years ago rather than 15 years ago, and it has been a highly integrated and highly accelerated plan through all of those years.

The second thing is that the Soviets do not hestitate to limit the choice of their young men and women so that they get the number of people in science and engineering that they want. For example, as of mid-1955 we had 108,000 people with doctors of philosophy and doctors of science. Only 83,000 Soviet citizens held the so-called kandidat degree, which is comparable to our doctor of philosophy. But out of the 83,000 that they have, 72,000 are in scientific fields, while of our 108,000, only 55,000 were in science fields. So they actually have at the doctorate level 72,000 people as against 55,000 of our own in the fields of science.

Representative DURHAM. Well, your figures there include all doctor's degrees, that is, sociologists and everything else?

Mr. HILLIARD. The first figure that I gave did—information we think is pretty good and the best we have, but they have only 83,000 in all fields and we have 108,000. That is all fields of training. But, of their 83,000, 72,000 are in the fields of science, whereas of our 108,000, there are only 55,000.

Representative DURHAM. Even at those figures, on a percentagewise basis, Russia would show a decided increase and also that she is gaining over us; would they not?

Mr. HILLIARD. Certainly the trend at the present time is in that direction.

Representative DURHAM. When you look at the secondary schools we have in this country, the enrollment last year was 6,600,000 pupils. Now, in 1939, the last accurate figures I expect we have for Russia's total enrollment in secondary and primary schools, it was a total enrollment of 10,773,000. Now, it was some 10 years before 1952 and 1953, at that time it was a good deal more than our enrollment and of course their population is larger. Our enrollment was 6,600,000 as compared to their figures. I cannot understand if they are making advances which we are told about. How they did it is what puzzles me. There is something wrong with our educational system, and if that is so we ought to take a very serious look at it.

Mr. HILLIARD. Although I have personally studied this somewhat, I certainly do not want to represent myself as an expert on Russia. However, I do have 1 or 2 views on it. One is that I think we do tend to underestimate what we ourselves are doing, and to somewhat overestimate what the Soviets are doing. Dr. Brownell, I believe, will indicate to you, there are specific ways of measuring this tendency to discount or to overestimate. At the same time, the Soviets have approached this problem unquestionably as a matter of using science and technology as an instrument of national policy and for that reason they have simply shunted people into that field to a degree that we would not want to do in this country. We feel that the freedom of choice is one of the things that we are mobilized to defend. This is something that they do not contend with, and they do not regard this as a particularly valuable thing at all. So they are using their manpower as a commodity to an extent that we would not regard as consistent with our way of life.

Representative DURHAM. We value this as one of our strong defense arms, for the defense of the country, these scientific personnel that we have in this country, because I think that we are all aware of the fact that someone like Einstein produces enough in 1 year to take care of all of us.

I am still somewhat puzzled at statements that continually come before this committee and also the Armed Services Committee, of the fact that the Department of War or the Department of Defense continually stresses the fact that they are continually gaining on us, and we still sit here and say that we will not make any gains in 5 years.

Mr. HILLIARD. I would like to correct that, if I did say it, or even if I was understood to have said it. I was attempting to say that as of now we have over 1 million trained scientists and engineers. How long would it take us to produce 10 percent of that million? It would take us quite a length of time, and the result is that rather than sitting back and focusing our attention on doing something to reconstruct our educational system, it is not going to be too worth while to us if in the meantime, in the next 5 or 10 years, the Russians overtake us in crucial weapons and we do not have a chance to carry out the long-range program that would be necessary.

I only want to emphasize that we should not focus our attention on the long term to the exclusion of realizing that we have some critical problems in the short term.

Representative DURHAM. I think that we all expect this problem to grow more acute. I think that we are living in a technological age and we cannot avoid the fact that we have got to do something to try to keep our position in the world. I think the President in his statement was referring to probably another matter on which I agree to a certain extent, that we should use all of our technological ability and brains to try to help the underdeveloped countries as far as we can. But when it comes to a matter of purely national defense, we have to think of it in other terms. Certainly I do, because I think it is just as essential in trying to do something in case we are ever faced with another situation like we have been faced with in former times, and we have to have the brains to help us do something about it. The other people are going to have them, according to the reports that we get.

I assume that they have the ability just as much as we do. They have proven that. So I am not suggesting any radical change in our educational system, I believe wholeheartedly in that, but I believe we have to have some different applications or difference ways of getting at this problem and trying to solve it.

Representative HINSHAW. I would like to observe, Mr. Chairman, that as a company commander away back in the distant World War I, which we called the Great War, we were on the lookout for some people who could run railroad locomotives and steam shovels and things like that. There was not a single person in the outfit that admitted that he could run a railroad locomotive or a clamshell bucket, or anything else like that, either engines in motion or stationary. Nobody would admit it. Nobody would admit anything that he could do except be a common laborer. But we had to find these people and we knew they were there. We began to put up inducements and before we got through we found more people that could do more things than

you could possibly imagine. Now, I think that some inducements have got to be offered to the people or young men who are getting along in the world to encourage them to engage in these very fine professions. Part of that inducement is the recognition and the honor that they can achieve by having done those things or that thing. I do not think that that is the highest service to the United States. I think probably in the next war we will find that the highest service to the United States is performed by the man who contributed mightily to the design of a great weapon such as the Nike, and we could name a number more.

Goodness knows the people who are trying to make the ICBM are screaming for high-grade talent. It takes a lot of it. Such a weapon is perhaps 60 percent electronics and the balance weapons material. The airplane today has gotten to be 55 percent electronics and some percent engines and the rest of it the frame. It is a matter of building a frame around a lot of gadgets. Someone has to design the gadgetry. Someone has to test it and to maintain the gadgetry afterward. You take an electronics engineer who is a college graduate, and maybe a master of science, into the Army and assign him, and they frequently do this, as part of the scheduling, as a maintenance engineer. That is on the line or in the rear. It is ridiculous, because he is a qualified engineer. His highest duty to the United States is in design and not in the maintenance of equipment. I agree with you that it takes these people to train maintenance engineers, but maintenance engineers do not require college degrees. They require skill in their hands and in their eyes and perhaps to some degree in their brains. I think that the utilization of manpower, if I might make so bold as to say so, that we have done so far, has made an awful lot of mistakes. I can point to one very serious mistake. We drafted a young man from the NACA Laboratories down here at Langley Field. He was the man who had done the skin-friction calculations on the X–1, the most complicated thing imaginable, and yet his number came up and so he was drafted.

He did not want to go into the Army because he was interested in aircraft. So what did he do? Instead of taking the 2 years' military in the Army, he said, "I will take 4 years in the Air Force," and he enlisted. He had tried everything he could do himself to get assigned to some scientific project in the Air Force, but nobody paid any attention to him. So he heard that we here were interested in such things and so he wrote a letter. You know what he was doing! Can you imagine? He was blowing a bugle in the Air Force band when I found him. If that is not a waste of manpower, I would like to know. These people have got to be encouraged to admit that they have these talents. They are not going to admit that they have the talents so long as they think that it is going to be held against them.

They have got to be honored to get them to come out and admit having talent, that is the problem. That will bring them forward. Whatever the program is in the military, of course the Joe Palooka always thinks the highest service is as Joe Palooka, but the Joe Palooka would not be able to move around if it were not for the guy with the brains.

I am for them both, but I think that we ought to utilize definitely every ounce of brainpower that we have got in the United States to do the best we can for our country.

Representative PRICE. Thank you very much for your fine statement.

The next witness is Dr. Samuel M. Brownell, of the Office of Education, acompanied by Mr. Henry Armsby of that office.

STATEMENTS OF DR. SAMUEL M. BROWNELL, COMMISSIONER OF THE OFFICE OF EDUCATION, DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE, AND HENRY ARMSBY, SPECIALIST IN ENGINEERING EDUCATION IN THE OFFICE OF EDUCATION

Dr. BROWNELL. Thank you, Mr. Chairman. I have with me today Mr. Henry Armsby, who is a specialist in engineering education in the Office of Education, and I would just like to say, as we start out, that it is my understanding that you would like to have us here to answer questions in reference to your particular problem of manpower and we are very glad to do anything we can.

I would like to have Mr. Armsby, if I may, present the statement which he prepared, and then I will try to supplement the information more or less informally, and we will be very glad to answer any questions. The reason I suggested that is because Mr. Armsby has to be away tomorrow and I thought in case we did not finish I would like to have him give his testimony, if that is satisfactory.

Mr. ARMSBY. My name is Henry H. Armsby. I have been on the staff of the United States Office of Education since March 1941. My present position is Chief for Engineering Education, in the Division of Higher Education. I have been a member of the American Society for Engineering Education since 1917, have been a vice president of the society, and am now serving my 11th year as a member of the general council, the governing body of the society. I have served and am serving on many important committees of the society. Of chief import in connection with these hearings, I have been a member of the society's manpower committee since its first appointment in 1946, and one of the society's three representatives on the engineering manpower commission ever since its creation in 1950.

Since 1949 the society and the Office of Education have been collaborating in the annual collection from the colleges of data on engineering enrollments and degrees, under my general oversight. The data are published in separate annual reports by the society and the Office, of such nature that they supplement, rather than duplicate, each other. Actually, both reports are written by a staff member of the Office of Education's research and statistical standards section and myself. Prior to 1949 the most detailed figures available were those collected by the society, which unfortunately did not represent as complete coverage as we have been able to get. Our reports cover all accredited institutions which report that they confer degrees in engineering.

In the belief that it may assist the Joint Committee in its consideration of the engineering manpower problem, I should like to present a little of the background information with reference to the present situation. I should also like to present a few more recent facts and predictions than those contained in the committee print recently published by this committee. So frequently in such a rapidly developing field figures in a printed report are outdated almost before the report is printed.

In the early spring of 1946 the American Society for Engineering Education, concerned about the shortages of engineers resulting from wartime practices, and also about the impending wave of veterans, appointed what came to be known as the Compton committee, its chairman was the late Dr. Karl Compton, president of the Massachusetts Institute of Technology, to study the general engineering manpower situation. I was fortunate enough to be a member of that committee. We surveyed industrial and governmental needs, and secured estimates from the colleges of the numbers of freshmen and total students they could accommodate. We reported in June 1946 our belief that the war-induced shortage could be made up by 1952.

This prediction was based on the estimates of the colleges that they could accommodate a maximum of 56,000 freshmen and 155,000 total students. When the fall enrollment was found to be 93,000 freshmen and 225,000 total students, 50 percent over the estimated capacity, I was asked by the land-grant colleges to reevaluate the Compton report. My report in December 1946 predicted a surplus of engineers by 1949. A few days later the ASEE Manpower Committee was appointed, and I have had the privilege of serving on that committee ever since. Up to June 1949 our annual reports reflected our growing belief that the danger of a surplus was diminishing.

In January of 1950 the engineers joint council issued a report indicating that a large sampling of employers of engineers expected to hire fewer engineers in 1950 than they had in 1949. This report, coupled with the largest senior class in history, led to many prophecies of a serious surplus of engineers. Many tables and charts were presented to the public, including wall chart 10 published by the Bureau of Labor Statistics, which indicated graduating classes rising to a peak in 1950 of about 50,000, and which many readers thought indicated that classes of this size could be expected in future years. In all fairness, it must be said that neither the chart nor the report said this, and that even the engineering colleges were expecting difficulty in placing their graduating classes that year. The graduates in 1950 actually numbered nearly 53,000.

Most of these prophecies of surpluses, including my own earlier ones, failed to take into account the rapid decrease in the number of freshmen entering engineering colleges since the first wave of veterans, from 93,000 in 1946 to 42,000 in 1949. In the spring of 1950 population trends indicated a still smaller freshman class for that fall. I issued a statement in "Higher Education," the United States Office of Education periodical, dated April 1, 1950, under the title "Engineers—Too Many or Too Few," calling attention to the rapidly declining freshman classes, giving some of the reasons for the constantly rising demand for engineers, which had previously been underestimated, and closing with a forecast of a shortage of engineers by 1952 or 1953. This statement, together with a letter from President Saville of ASEE, was given wide circulation among high schools.

A little more than 2 months later, in June 1950, the outbreak of hostilities in Korea created such a sharp increase in the demand for engineers that the shortage developed within a few months instead of a few years. It has been with us ever since, and all available evidence points to its continuation for a good many years to come.

I have attached 2 tables to my statement (pp. 197–198), the first of which is entitled "Enrollment and Engineering Degrees—Record and

Forecast, 1935–65," which is a revision of the table with the same title which appears on page 14 of the Joint Committee Print previously mentioned. The revisions are due to firm figures for 1 more year replacing earlier estimates, to recently revised estimates by the Office of Education on total freshmen up to the year 1960, and to a few unimportant errors which have been found in my table dated March 3, 1955, which was copied in the Joint Committee Print.

This first table shows very easily that from 1946 to 1949 freshmen engineers declined not only in total members, but also as a percentage of all college freshmen. Prior to World War II, engineering freshmen had averaged about 8 percent of total freshmen. In the fall of 1946 this had risen to 13.4 percent. The percentage declined steadily until the fall of 1950, when it was 6.6 percent. This was the low point, both in numbers and percentage, the 34,000 freshmen that year being the smallest class since 1944, and the percentage the smallest since 1935.

Incidentally, all figures down to the double line are historical data. The other figures are estimates.

These graduates, up to 1939, as shown on this table, are based on students now in college. Beyond that they are based on the office projections of total freshmen, which are thought to be reasonable in view of population and educational trends. All of these projections are based on a continuation of present Selective Service regulations and present general economic and industrial conditions.

The second of the attached tables, entitled "Trends in Engineering Education—1939–40 to 1955–56," compares engineering enrollments and degrees with those in college education as a whole. Prior to the year 1949–50 there are gaps in the data, and some of the figures shown are estimates. Since 1949 the data are complete. In spite of its deficiencies, this table shows certain trends quite clearly. 1939–40 is used as a base because it was the last prewar year for which fairly complete data are available.

Both the all-college freshmen, column 2, and engineering freshmen, column 3, recorded alltime highs in the fall of 1946, the former being about 167 percent of the 1939 value—the latter 293 percent.

I am going to use this kind of a comparison with the 1939–40 figures, and shall refer to such percentages as "coefficients" during the remainder of this statement. All college freshmen then decreased to a low coefficient of 113 in 1951. Engineering freshmen reached a low coefficient of 108 a year earlier. Since then both have increased every year, the all-college freshmen to 165 last fall, which is 99 percent of their peak value, the engineering freshmen to 229 which is 78 percent of their alltime peak.

From 1950 to 1953 freshmen engineers increased more rapidly than all college freshmen, as shown by the percentage figures in column 4. Since 1953 the two groups have grown at about the same rate, with engineers constituting a larger fraction of the total than in the prewar years.

The all-college enrollment, shown in column 5, which in 1946 had a coefficient of 152, continued to grow until 1949, when its coefficient was 180. After dropping slightly for 2 years it has risen for 4 years to a new alltime high last fall of 200. That is the figure of 2,720,000 total college enrollments.

Total engineering enrollment, column 6, reached its alltime maximum coefficient of 225 in 1947. It then declined more rapidly than the all-college enrollment to a low in 1951 of 153. Since then it has risen at a slightly faster rate, and last fall had reached 225, still below its previous peak.

As was expected, the record freshman class of 1946 produced a record number of bachelor degrees in 1950, columns 8 and 9. The all-college coefficient was 233, engineering was 462.

Last year's all-college coefficient was 154, the engineering coefficient was 198. Engineering bachelor degrees as a percentage of all-college bachelor degrees declined steadily from 1947 until 1954, and turned up slightly last year.

In graduate degrees also, columns 11 and 12, the number in engineering have had a greater percentage increase since 1939 than the all-college number; the former in 1955 having a coefficient of 223, the latter 365. Both were at about 90 percent of their peak values, which occurred 1 year after the peaks in bachelors degrees, as might be expected.

Various studies have indicated that industry can use to advantage from 2 to 5 technicians to each engineer. Enrollments in technical institutes have been increasing somewhat faster than in engineering colleges. A study by the Technical Institute Division of the American Society for Engineering Education covers 200 institutions, which in 1954 graduated about 10,000 students. In 1955 they graduated about 12,000, an increase of 20 percent. But this is only about half a technician to every engineer instead of the 2 to 5 technicians industry could use.

The trends in enrollments and degrees shown in these tables seem to indicate that the efforts of the many agencies concerned with engineering manpower have had some effect, that after a decline of several years in engineering graduations we have "turned the corner" both in numbers and percentagewise, and that larger classes are in prospect for the years ahead than in the immediate past.

However, the needs for engineers have also been increasing. The number of bachelors degrees in engineering anticipated through the school year 1958–59, based on students now in college, is about 143,000. The need for engineers is estimated by the Engineers' Joint Council and the Department of Labor's Bureau of Labor Statistics, our most reliable sources of information, to be about 40,000 per year under present conditions of partial mobilization. This indicates a need of about 160,000 engineers for the 4 years, leaving a deficit of about 17,000, which must be added to the present estimated deficit of about 40,000.

Furthermore, the ratio of engineers to total employment has steadily risen ever since statistics in this field have been kept, because of the increasing complexity of our technological economy. It seems probable that it will continue to rise, which will still further increase the need for engineers. And certainly, if the Nation is forced into a condition of all-out mobilization or actual warfare, the demand for engineers, both by the Armed Forces and by industry, will be greatly increased.

(The tables referred to follows:)

Enrollments and engineering degrees—record and forecast, 1935–65, by Henry H. Armsby, Apr. 15, 1956

[In thousands]

	Freshman students			Engineering degrees					
				Bachelors			Masters		
Academic year	Total	Engineering	Ratio, (3)÷(2)	Academic year	Number of degrees	Ratio, (6)÷(3)	Academic year	Number of degrees	Ratio, (9)÷(6)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
			Percent			*Percent*			*Percent*
1935–36	367	24	6.5	1938–39	13	54	1939–40	1.3	10
1936–37	----	30	----	1939–40	14	47	1940–41	1.4	10
1937–38	368	33	9.0	1940–41	13	40	1941–42	(1)	----
1938–39	----	32	----	1941–42	(1)	----	1942–43	.6	----
1939–40	418	32	7.7	1942–43	14	44	1943–44	.5	4
1940–41	----	33	----	1943–44	11	33	1944–45	.5	5
1941–42	379	35	9.2	1944–45	4	11	1945–46	1.0	25
1942–43	----	36	----	1945–46	6	17	1946–47	3.1	45
1943–44	251	17	6.8	1946–47	19	53	1947–48	4.4	23
1944–45	----	18	----	1947–48	29	161	1948–49	4.8	17
1945–46	475	42	8.8	1948–49	45	107	1949–50	4.8	11
1946–47	696	93	13.4	1949–50	53	57	1950–51	5.0	10
1947–48	593	64	10.8	1950–51	42	66	1951–52	4.0	10
1948–49	569	53	9.3	1951–52	30	57	1952–53	3.6	12
1949–50	558	42	7.5	1952–53	24	57	1953–54	4.1	17
1950–51	517	34	6.6	1953–54	22	65	1954–55	4.4	20
1951–52	472	40	8.5	1954–55	23	58	1955–56	3.5	15
1952–53	537	52	9.7	1955–56	30	57	1956–57	4.5	15
1953–54	571	60	10.6	1956–57	34	57	1957–58	5.1	15
1954–55	642	66	10.2	1957–58	37	57	1958–59	5.6	15
1955–56	690	72	10.5	1958–59	41	57	1959–60	6.1	15
1956–57	706	74	10.5	1956–60	42	57	1960–61	6.3	15
1957–58	727	76	10.5	1960–61	44	57	1961–62	6.6	15
1958–59	741	78	10.5	1961–62	45	57	1962–63	6.7	15
1959–60	771	81	10.5	1962–63	46	57	1963–64	6.9	15
1960–61	828	87	10.5	1963–64	50	57	1964–65	7.5	15

[1] No report.

NOTE.—Figures above double line are from reports of Office of Education and American Society for Engineering Education. Figures below double line are estimates.

Trends in engineering education, 1939–40 to 1955–56—engineering enrollments and degrees compared with total college enrollments and degrees

[In thousands]

Academic year	Fall enrollments					
	Freshman			Total		
	All college	Engineering		All college	Engineering	
		Number	Percent of total		Number	Percent of total
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1939–40	[1] 418.0	31.8	7.7	1,364.8	108.4	7.9
1940–41		33.2			114.1	
1941–42	[1] 379.0	35.0	9.2	1,180.4	112.7	9.5
1942–43		36.4				
1943–44	[1] 251.0	[2] 16.6	6.8	733.2	[2] 48.1	6.6
1944–45		[2] 17.3			[2] 38.0	
1945–46	[1] 475.0	[1] 42.0	8.8	1,073.6	[1] 88.0	8.2
1946–47	696.4	[1] 93.0	13.4	2,078.1	[1] 225.0	10.8
1947–48	592.8	[1] 64.0	10.8	2,338.2	244.4	10.4
1948–49	568.8	[1] 53.0	8.3	2,408.2	241.6	10.0
1949–50	557.9	41.8	7.5	2,456.8	219.7	8.9
1950–51	516.8	(34.3)	(6.6)	2,296.6	180.3	7.8
1951–52	(472.0)	39.6	8.4	(2,116.4)	(165.6)	(7.8)
1952–53	536.9	51.6	9.6	2,148.3	176.5	8.2
1953–54	571.5	60.5	10.6	2,250.7	193.3	8.6
1954–55	642.4	65.5	10.2	2,499.7	214.4	8.6
1955–56	689.6	72.8	10.5	2,720.9	243.2	8.9

Academic year	Degrees granted					
	Bachelors			Graduate		
	All college	Engineering		All college	Engineering	
		Number	Percent of total		Number	Percent of total
(1)	(8)	(9)	(10)	(11)	(12)	(13)
1939–40	186.5	11.4	6.1	30.0	1.4	4.7
1940–41		12.7			1.5	
1941–42	185.3			28.1		
1942–43		[2] 14.1			[2] .7	
1943–44	125.9	[2] 10.6	8.4	15.7	[2] .6	3.8
1944–45		[2] 4.2			[2] .5	
1945–46	136.2	7.4	5.4	21.2	1.1	5.2
1946–47		19.3			3.3	
1947–48	(272.3)	28.9	16.8	(46.4)	4.6	9.9
1948–49	366.7	45.2	12.3	55.8	5.2	9.3
1949–50	433.7	52.7	12.2	64.9	5.4	8.3
1950–51	384.4	41.9	10.9	72.5	5.7	7.9
1951–52	331.9	30.3	9.1	71.3	4.7	6.6
1952–53	304.9	24.2	7.9	69.3	(4.3)	(6.3)
1953–54	292.9	(22.2)	(7.6)	65.8	4.8	7.2
1954–55	287.4	22.6	7.9	67.0	5.1	7.6
1955–56						

[1] Estimates.
[2] Civilian students only.

NOTE.—Engineering figures prior to 1949–50 from ASEE, all other figures from USOE.
Highest value in each column is boldface, lowest since 1946 is in parentheses.
Prepared by Henry H. Armsby, Apr. 16, 1956.

Representative PRICE. Mr. Armsby, your statement of the statistics given there are convincing testimony that the problem does exist. I wonder if you could tell us what the Office of Education is doing or what responsibility it may have in trying to do something about the problem?

Dr. BROWNELL. I would be very glad to answer that, if you do not mind, because I would like to do it on an overall basis on science, mathematics, engineering and so on.

I might say that the Office of Education has the responsibility for the collection of information and the dissemination of information but it does not operate schools. Therefore, our job is essentially a teaching and public information job in that respect. We have been concerned about this problem in a number of ways for several years. Mr. Armsby, himself, as the engineering education specialist, has indicated to you activities in which he has engaged over a number of years. I might say that about 2 years ago, shortly after I came to the Office of Education, I participated in a meeting that was held by the American Association for the Advancement of Science in Berkeley, Calif., at which time the various scientific people in this country, through their organizations, spent a considerable portion of their time in discussing how they could improve the situation through getting more science taught in the high schools and getting better prepared high school teachers. They adopted, as a result, a program which was an official program of the American Association for the Advancement of Science. In that, the Office of Education has been participating.

I mention that because that shows that we have been operating not just within the past few months, but over some period of time.

I would like, also, to point out that the Office of Education was instrumental, along with the National Science Foundation, in calling a meeting of the officers of the scientific societies, and the executive committee of the American Association for College Teachers of Education to bring together the scientists and the teacher-education people into partnership or closer partnership in seeing what they could do to improve the production of science, mathematics, and engineering people.

Likewise, the Office of Education took the initiative in bringing together representatives of Government agencies, the Office of Defense Mobilization, the Department of Defense, National Science Foundation, the National Academy of Science and the American Association for the Advancement of Science to see that on a monthly basis we would exchange information on the progress being made so that all of us could be kept informed and help inform the public of what was going on.

Now, the publications of the Office have included several that dealt with the problem of engineering education. Mr. Armsby has been the author of those.

Mr. Osbourn, who is on our staff as a science specialist, and Mr. Brown, who is a specialist in the field of teaching of mathematics, has been very active with the different groups that are working on this problem.

I should say that there is a great deal that is being done by scientists through their organizations, as well as by the different arms of the Government in trying to increase the interest and activity in this field. Very recently we participated in the meetings of the National Personnel and Guidance Association (and members of the National Science Foundation and the Office of Defense likewise participated) to bring to the attention of guidance officers in schools and colleges

information so that they, in turn, in working with students could present that information.

We participated recently in a meeting of the National Science Teachers, who held their meeting here in Washington. To my knowledge it was the largest meeting that they have ever held. It was an indication of the increased concern on the part of secondary schoolteachers in this problem.

Those are just instances and I could multiply them, and I could supply considerable amount of documentary evidence of different sorts of things that are going on and have been going on in the last several years to alert school people, including students, to this problem.

I think the figures which Mr. Armsby has presented in reference to the engineer picture indicates two things. One is that in reference to the total population in school age there has been a greater than normal increase in the number that have been going into the science and engineering field. That is, of course, hopeful as a means of increasing the number of people who will be trained.

Representative DURHAM. How about turning them out at the end of the 4 years, or the 6 years? You say there is an increase going into the subject of science, but how about your finished product; is that on the increase?

Dr. BROWNELL. Yes. I think that I could show you this chart which is one of the charts we use to keep track of the situation. This blue line, if you can see it, represents the persons age 25 to 64 in our total population. This red line indicates the number of teachers which you can see parallels pretty much the increase. This goes from 1880 up to 1950 to show the trend.

Representative PRICE. You do estimate an increase in the number of graduates and that has been taken in consideration when you base your overall figure on shortage. You still have your 40,000 shortage even with the increases suggested here.

Dr. BROWNELL. I want to make it perfectly clear that we are not trying to minimize the situation, nor are we trying to build it up. We are just trying to give you the facts.

Representative PRICE. As a committee we are not even thinking about legislation here right now. We are trying to get at the nub of this problem and trying to see what it is and to alert the country to it, and alert the educators to it so that it can be brought into the open and talked about and people who are closest to it can express themselves openly and freely so that we will know what the problem really is. That is all we are attempting to do here.

Dr. BROWNELL. We appreciate it because that is just what our job is, to try and get these facts out to the people.

Representative DURHAM. Of what effect is the leveling off of the teacher problem there? I notice your red line is leveling off, and your other line is still on the upgrade.

Dr. BROWNELL. If I may, I will go back to this chart. This chart has to do with the numbers of people in different occupations in our total population. Here is the total population and here is the teachers in it.

You asked the question about the leveling-off effect there of the teachers. It shows our increased teacher problem that we have had, beginning back here about 1930. Instead of the number of teachers

increasing about the same rate as our population, it leveled off, and you see the efforts that have been made since around 1940 to increase the supply of teachers have had some effect.

Representative DURHAM. It creates quite a problem, does it not?

Dr. BROWNELL. Yes, and we are not getting as many teachers as we should have, but at least we have made some progress.

If you look down here at this line, this is the engineers in our total population. That is this black line. You can see, going back there, how rapidly there has been an increase in the engineers in our population. That shows the impact of science and technology.

Representative DURHAM. That begins about 1930.

Dr. BROWNELL. In 1940 up to 1950 is when you have the biggest increase.

Representative DURHAM. The beginning of the line is what date?

Dr. BROWNELL. That is 1880. This goes clear back, and this is our long-range point of view. We went along without too much increase in the number of engineers and, in fact, the percentage of engineers in our total population was less or about the same in 1900 as it was in 1880. Then it began to rise and in the past years the engineers have increased materially. These other two lines are put in here to show two other fields; one happens to be lawyers and the other is physicians and surgeons.

The point I am making is to show how, in our total population, we have increased rather dramatically the percentage of engineers.

Representative DURHAM. What is your most active participation in this problem? Is it just holding conferences and trying to educate the people as to the need, or do you go beyond that to any extent? Of course, I realize your limitations in our system of education. Is that your main job?

Dr. BROWNELL. We have three things that we do. One is collect facts and information so that we can make it available. The type of information, for instance, that Dr. Armsby has presented to you on engineers; we make that available, and we do the same in other fields.

Representative DURHAM. That is distributed to all institutions?

Dr. BROWNELL. That is made available to all institutions through publications and through our participation in various activities on which we are called to participate.

Representative DURHAM. Do you mail it or are you asked for it?

Dr. BROWNELL. We have a monthly magazine called School Life and another one, Higher Education.

Representative DURHAM. Do you think it is being distributed at the present time so that the information is available to practically all institutions of the country, or is there some lack of distribution?

Dr. BROWNELL. I think the information we have is very widely used, but I do not think we are doing as much as we should and we have requested, in our budget, funds to increase our collection of statistics and our publications because we believe that the information should be more widely available than it is at the present time.

Representative PRICE. Doctor, in that connection, there was some criticism this morning by one of the witnesses or a suggestion, let us put it that way, that the Office of Education expand its facilities in this regard and that they considered your operations in your scientific division too limited and too small an operation.

Dr. BROWNELL. I would say this: That we requested this year an increase in the funds for salaries and expenses in the Office of Education, which was recommended by the President from approximately a $3 million budget to a $6 million budget, and part of that we asked for was in order to expand our statistical services and our publication services, and to get into research, which I wanted to mention a few minutes later, but I will do it right now.

We feel that some of these problems that have been posed and you have been discussing call for considerable research in the way that we have attacked our problems of science and technology, agriculture and medicine and so on, to see how we can better utilize the human resources that we have.

One of the proposals we had in our budget this year was that we should study this whole question of how you utilize to better advantage and develop to better advantage the special abilities of students. Now, we know that there are a great many students of special ability who are dropping out of school before they have secured as much education as they could profit from. We likewise know that there is a great waste in the fact that a good many of our talented students are not discovered until they are well along in school, and the kind of education they receive is not up to their capacity.

Now, those are kinds of wastes in human resources that we think are tremendously important from the standpoint of the Nation.

Representative DURHAM. Do you have difficulty in securing scientific personnel in your own department?

Dr. BROWNELL. In the Office of Education of the United States, we have one engineering education specialist, and one science education specialist, and one mathematics education specialist.

Representative PRICE. Do you consider that to be adequate in this program?

Dr. BROWNELL. No, sir.

Representative PRICE. What did you ask for in the budget?

Dr. BROWNELL. The Bureau of the Budget has recommended a $6 million budget and the House Appropriation was $4.5 million.

Representative PRICE. What would that do, and how much would that increase your staff?

Dr. BROWNELL. That would increase our staff by approximately a third; and the other part, the place where we had about $1.5 million of our increase or a little more, was for research which would be carried on in colleges, universities and State Departments of Education, realizing that that is where the research talent lies and the research in education can be developed best there rather than to set up a big research organization here in Washington.

Representative PRICE. Where are you going to get it from?

Dr. BROWNELL. The Congress approved 2 years ago this authority for the Office of Education to engage in cooperative research. The funds we asked for were in order to implement that program because the funds that were requested a year ago were not approved. But we feel, if we are going to move ahead in the utilization of our human resources in this country on an efficient basis, we have to go after that problem the same as we have gone after the development of our natural resources.

Representative DURHAM. Are you the only group in the United States that is doing research work to any degree, or are some of these

other research foundations doing a lot of this work in education that gives you information?

Dr. BROWNELL. There is a considerable amount of research going on in our institutions of higher education and by the foundations. The amount of money that is going into research in education, compared to the amount of research that is going on in the field of health and in the field of science and technology, however, is very small.

Representative DURHAM. I am referring primarily to technological personnel and scientific personnel. What I was wondering about was whether or not something like the Ford Foundation or others of that category do research work which would become available to you, which would be of some advantage in this scientific section of your department?

Dr. BROWNELL. Oh, yes, any research that is done by those places, we try to become acquainted with and utilize.

Representative DURHAM. It is correlated, then, to a certain degree?

Dr. BROWNELL. That is one of the things that we ask funds for so that we could become the coordinating center for research in education, because there is no coordinating center for research in education at the present time.

Representative DURHAM. That is not so good.

Dr. BROWNELL. It handicaps those people who are doing research not to have a cordinating center.

Representative DURHAM. That is why I asked you the question.

Dr. BROWNELL. Yes.

Representative DURHAM. What efforts are being put forth? Will those funds make that entirely available to you; if you had the necessary funds from the Congress?

Dr. BROWNELL. Our budget this year for salaries and expenses in the office was $6 million. The House appropriated, in its action, $4.5 million. Now, the Senate has not acted on the Office of Education budget, so I do not know what action will be taken there.

Representative DURHAM. Has that section been running around that amount of money, about $4 million?

Dr. BROWNELL. No, the Office of Education has been running with a budget of approximately $3 million now for the last few years.

Representative DURHAM. I am referring primarily to this section. Your overall budget is how much?

Dr. BROWNELL. The overall budget for the Office of Education is divided into two parts. One part is the money that is distributed to the States under the Land-Grant College Act, and the vocational education and the school assistance program.

As far as the Office of Education is concerned, that does not mean anything except a job to disburse it, and about a third of our staff is involved in handling the school assistance in federally-affected areas. Another group are involved in administering the vocational education fund.

Actually, in terms of the total Office of Education staff, where we have at the present time about 500 people, there are 76 people that are available for research and services in the field of education. So that the Office of Education staff is involved to a very large extent in providing information to the Congress and getting out these publications in such areas as we can collect and organize the data.

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Representative DURHAM. We had a meeting some months ago and do you feel that that stimulated a lot of interest?

Dr. BROWNELL. We have a good deal of evidence that it did.

Representative DURHAM. That was the conference held here some time ago.

Dr. BROWNELL. Yes, and we are in the process of doing some of that evaluation now, but I can say that we already know that it has stimulated a lot of activity in the States and in the local communities, which was the intention, in getting them to increase their funds for education and to reorganize school districts.

Just yesterday, or the day before, an analysis was placed before me which showed that in the past year, this past legislative year, some 6,000 acts were passed by the 47 legislatures that met. Not all of those were the result of the White House Conference, but we know that a number of them grew out of the work in the State conferences showing up problems of reorganization and State support and so on that were passed.

Representative DURHAM. What did that include? Did it include all levels of instruction?

Dr. BROWNELL. That included elementary and secondary education, and the President will announce, as he indicated earlier—and we hope he will announce within the next few days—the appointment of a committee on education beyond the high school. That committee is to study all of these problems of education beyond the high school so that the colleges and universities and the States will step up their efforts to provide the education that is needed in this field.

Now, if you will recall the President also appointed Committee on Scientific and Engineering Manpower the other day and that will work very closely with this committee on education beyond the high school in that phase of the total program.

Representative DURHAM. Is the Department of Education included in that committee to be formed?

Dr. BROWNELL. The Office of Education has this kind of a liaison, that the Commissioner is an honorary vice chairman of the committee, and all of the way through in connection with the White House Conference, and I assume it will be true with this Committee on Education Beyond the High School, we have had liaison persons from the Office of Education who worked with the committee so that they could supply information that the Office had and keep the Office informed of the information that was being developed by the other committee.

So there has been a very close working relationship, although they are independent agencies as we recommended.

Representative VAN ZANDT. Doctor, in the past few years, we have listened to a lot of speeches and read a lot of statements and so forth concerning this shortage of manpower in the scientific field. Are you convinced that the subject is a live issue today, not alone in the field of education but also industry?

Dr. BROWNELL. Yes. I think we have to get still more concerned about the activity, but certainly we have pretty good evidence that a lot of progress is being made. I want to show you, if I may, another chart. It think it illustrates the point.

Now, these three columns, the height of the first column indicates the number of children 14 to 17 and this was in 1933–34. The second

shows the number in 1948–49. In other words, we had fewer young people in the age group of 14 to 17 in 1948–49 than we had in 1933–34.

The third column shows the number in 1954–55. You can see that it is beginning to build up again.

Now, the next part of the column shows the number of children enrolled in grades 9 to 12.

If you will notice those three, while the number of eligible people of high school age has decreased, actually the proportion enrolled in our high schools increased steadily. That means we have done a better job of holding in school some of those who dropped out.

Now, if you take the mathematics enrollment in our high schools, the number who were enrolled in mathematics in 1933–34 is indicated by that part of the column. The proportion enrolled in mathematics in 1948–49 increased, and the number enrolled in mathematics in 1954–55 was still higher.

Now, percentagewise, it is not quite as large a percentage because our enrollment grew, but actually in numbers of people—and that is what you have to count when you are getting your trained personnel, the reservoir on which the advanced work can be built is greater than it was in 1948–49.

Now, if you take the physics, chemistry, and biology, you will see the same sort of a situation; that there has been a constantly increasing number.

What we think is this: In order to supply the increased number that we need in the technological fields, we have to increase science and mathematics enrollment more than at the present time. But I think there is a pretty good evidence of the fact that people have been concerned, both our young people who have been choosing those subjects and our school people who have been working with them.

Representative VAN ZANDT. How many requests for information do you receive from industry where industry sets up their own classes to educate manpower for this particular field?

Dr. BROWNELL. We would probably get very few requests of one sort or another on that because those people would probably go to either their State Department of Education or to colleges and universities. They are more likely to go to colleges and universities for information in regard to curricula, staff, and that sort of thing. If they would write to us we may get those and then we will refer them to the sources of information where they can be helped if we do not have it ourselves.

Representative VAN ZANDT. I take it from your statement, Doctor, that the shortage of manpower is a live issue in the educational field today?

Dr. BROWNELL. It is more alive than it has been at any time.

Representative VAN ZANDT. What do you think Congress can do, to further stimulate the discussion and aid in solving the problem?

Dr. BROWNELL. I think what you are doing right now, making available information, is helpful. I think, likewise, that in terms of the long range as well as the short range, we must get busy on this research on our human resources.

Representative DURHAM. That disturbs me in one way. We were asked to spend this year, I believe, a total of something around $2 billion for research. Here you have a function of at least trying to make an effort to supply this personnel and you get less than you desire.

It is no trouble for us to sell a research request and it does not make any difference who it comes from. We just grant the money, period. We seem to be getting the "tail kind of wagging the dog" a little bit on this thing.

I serve on this committee and I serve on the Armed Services, and all of these requests come to us, and as I recall, it is something over $2 billion or something more than that this year.

Dr. BROWNELL. I had an analysis of the 1955 budget, leaving out Defense and just taking the regular departments. There were $228 million for research in the regular budget.

Representative DURHAM. That is a small amount besides what the Defense Department asks us for.

Dr. BROWNELL. Out of the $228 million for research, four-tenths of a million dollars, or $400,000, was for research in education. Now, what we requested this year, as I pointed out, was to get research in that field underway was in the neighborhood of $1.9 million.

Representative DURHAM. One primary function of your Department should be to keep in a position to be available to make information to industry or anybody else who desired it as to the number of personnel trained in the country.

Dr. BROWNELL. We try to do that as much as we can. Frankly, I am not here to ask for appropriations because this is not the Appropriations Committee. But if we are going to get information on our overall national needs, we have to collect the data and the only way you can collect the data is to get it from the source; and that takes funds to do it and when you get it to process it rapidly.

One of the things that has bothered me has been the fact that much of our information in the Office of Education was historical before it was current.

Representative DURHAM. We are told that we have to appropriate some very expensive research and I often raise a question of whether you have the scientific personnel to do it. I am always told that we have enough until a later time, and then everybody tries to cry about a shortage.

I think that we should look at the picture very carefully, as to whether or not the funds that we grant are being properly used and utilized by the brains of the country.

Representative VAN ZANDT. I have another question. I understand that the responsibility of government rests upon the shoulders of the Department of Education to give leadership so that we can overcome this problem. Is that right?

Dr. BROWNELL. We feel that we are not the only ones, but we certainly have a leadership responsibility. We think the Government, in its various departments, where they have information, the Congress is particularly in a position where it can give leadership to the development of information and the programs.

Representative VAN ZANDT. I probably should continue by saying that you cannot give the type of leadership that this demands without Congress giving you additional funds.

Dr. BROWNELL. That is our feeling, yes. We feel this way: That it is our responsibility to present programs to the Congress showing that we will give the kind of leadership that is necessary in such a way that the Congress will feel that it should be supported.

Representative VAN ZANDT. A moment ago you mentioned the long-range program. What do you recommend on the short-range basis to meet the present acute situation?

Dr. BROWNELL. The things that we are doing, I would say are all directed toward that. One is trying to bring together the education people, and the scientists and the Government people who are all working in the field, so that we can all keep informed of what each is doing and give that impetus.

The second thing is to get out the information just as broadly and as widely as possible as to what the needs are so that students and parents and teachers can know that there are needs for jobs and opportunities in that field. That causes them to do it.

The third phase has to do with this matter of inducements. There are many inducements, as you know, at the present time to give priority in the field of engineering and science over many other fields. Now, I think that is important. But I would also say that we must remember that just having more scientists and more technologists is not going to solve our problems in this nation. For us to get completely out of focus and just try to fill up the engineering needs might do us more damage than it would good. We always have to keep that balance, because we have shortages in elementary teachers, and shortages in high-school teachers, and shortages in nurses, and shortages in almost any field that calls for trained personnel. Part of the reason for that is that we have been having a decreasing number of people in this age group.

Now, here is the picture of what we have ahead of us, a very rapid increase in the number of persons who will be available to be trained.

That is very hopeful, and on the short-term basis now, if we get those people going into the fields that need training, that will help out. The point I was trying to make a moment ago was that actually we can see that that is happening. Maybe I can use this as an illustration.

Back here in 1950 was this line here. In 1950 it was the peak year of people that we had in college. It went down and this is the numbers of degrees that were given in 1955. This line, as you can see, shows the upturn in the degrees in 1956. Here is the line in the number of high-school teachers that were prepared and that started going up a year ago. That will be up still more this year according to enrollment. Here is the science teachers, the top number that were prepared and that went down, and you see that leveled off and that has started up again. The same thing is true in regard to the mathematics teachers. Both of those need to be increased more.

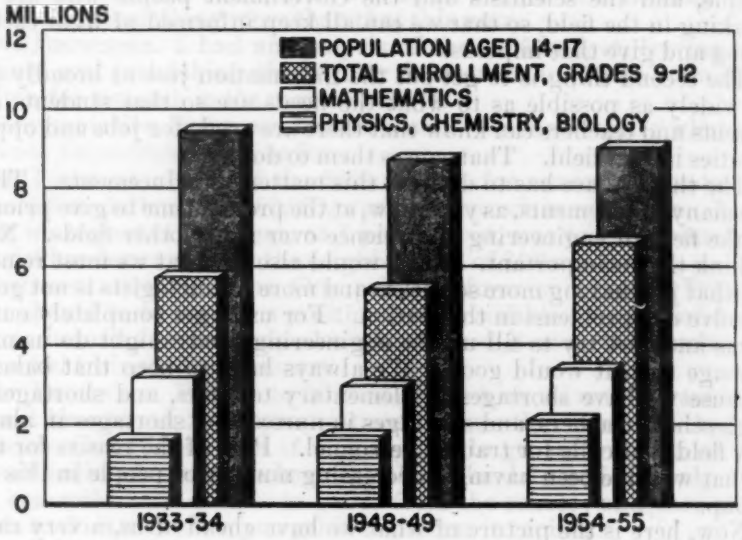
On the short-term basis, the point I would like to make is that the efforts that people have been making in the past 2 or 3 years are beginning to pay off. We have, in addition to that, the increased number of people who are going to be available of the college age group. If we can do a better job of utilizing or getting those people to stay in school and take the kind of preparation for the shortage areas we need, that is fine. That is what we are trying to do.

Representative DURHAM. I would suggest that those charts be submitted for the record.

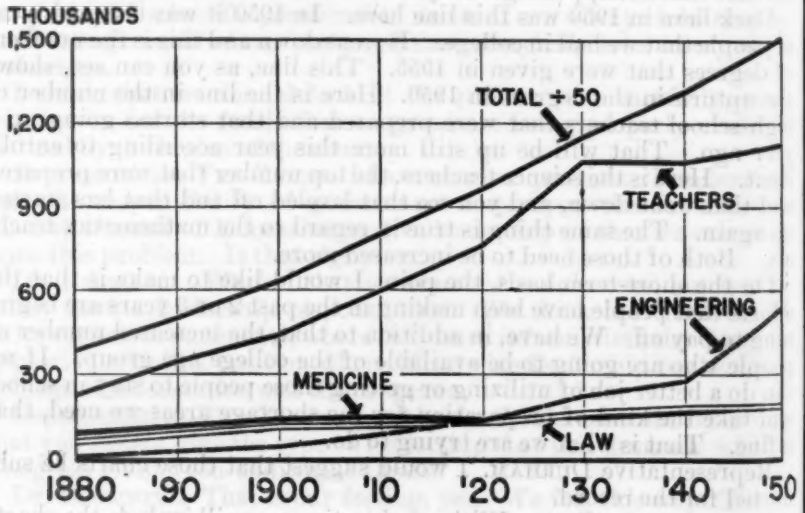
Representative PRICE. Without objection, we will include the charts in the record.

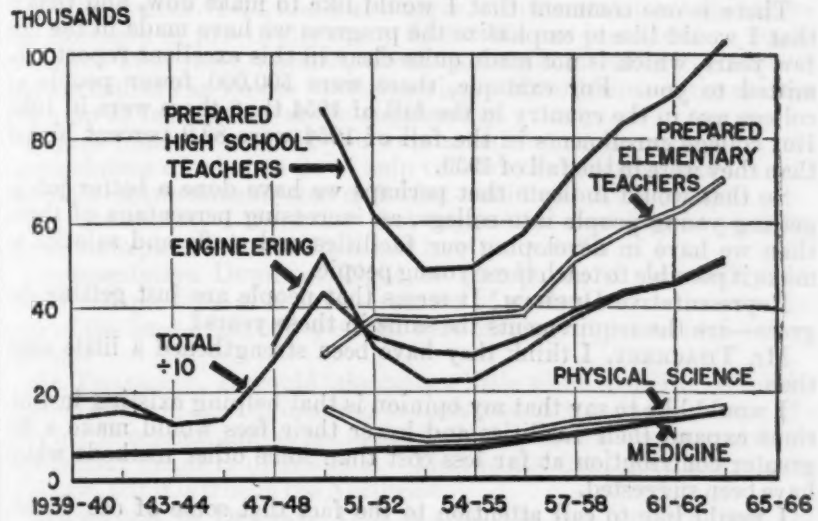
(The charts referred to follow:)

MATHEMATICS & SCIENCE ENROLLMENT
PUBLIC SECONDARY SCHOOLS



PROFESSIONAL PERSONS AND
POPULATION AGED 25-64





Representative PRICE. Are there any further questions?

Thank you very much. And, Mr. Armsby, we appreciate very much your cooperation and the fine statement that you have given.

Thank you very much, Dr. Brownell.

We know your figures are up to date and accurate, and they are very helpful to us.

The next witness is Mr. Russell Thackrey, American Association of Land-Grant Colleges.

Mr. Thackrey, we regret that it is such a late hour, but this certainly happens in these sessions. Would it be possible for you to introduce your statement in the record and we will include it and print it in the record without objection, and then you can make any direct comments you care to make.

I notice in reading your statement you have covered this subject, and I also noticed the last sentence of your statement. I think we would desire such recommendations.

STATEMENT OF R. I. THACKREY, EXECUTIVE SECRETARY OF THE AMERICAN ASSOCIATION OF LAND-GRANT COLLEGES AND STATE UNIVERSITIES

Mr. THACKREY. There are just 3 or 4 points that I might make at this time and then submit the statement for the record.

I might mention, first, that we are very much interested in this problem because, although the land-grant institutions enrolled about only 18 percent of the colleges and university students, we do graduate about 38 percent of all of the engineers in the country.

Representative PRICE. How many land-grant colleges are there?

Mr. THACKREY. There are 69, and our association includes 3 more members.

Representative PRICE. Which is the largest of them?

Mr. THACKREY. I suppose the University of California, with all of its campuses, is the largest.

There is one comment that I would like to make now, and that is that I would like to emphasize the progress we have made in the last few years, which is not made quite clear in this excellent report submitted to you. For example, there were 500,000 fewer people of college age in the country in the fall of 1954 than there were in 1939. But college enrollments in the fall of 1954 were 82.2 percent higher than they were in the fall of 1939.

So that would indicate that perhaps we have done a better job in getting young people into college, an increasing percentage of them, than we have in developing our facilities and staffs and salaries to make it possible to teach these young people.

Representative DURHAM. It seems that people are just getting degrees—are the requirements the same in those years?

Mr. THACKREY. I think they have been strengthened a little since then.

I would like to say that my opinion is that helping existing institutions expand their facilities and lower their fees would make a far greater contribution at far less cost than some other methods which have been suggested.

I would like to call attention to the fact that some of our States, including some which have fine colleges and universities, make it very difficult for their own young people to go to college as compared to the situation in other States.

Representative DURHAM. What do you estimate the cost is for a boy to get his college engineering in a land-grant college?

Mr. THACKREY. I do not have an overall figure, but I could supply it. However, it would vary greatly. In the New England States it would be much higher than it would be in the midwest, for example. I want to point out in the New England area the public universities have, in general, limited facilities and high fees and some of them are at the bottom of the country in the percentage of their own young people who go to college.

In 1949–50, Maine, Vermont, and Rhode Island were in the lowest 12 States in proportion of young people resident in that State going to college. The great industrial State of New Jersey, with a population of 4,835,000 in 1950 had 5,100 students enrolled in all of its engineering colleges while the great industrial state of Michigan, with a population less than 25 percent larger, had 13,000 engineering students enrolled in its institutions.

Representative DURHAM. Do you think that is due to the fees, Doctor?

Mr. THACKREY. It is due partly to the fees and partly to the facilities. I know that in New Jersey, Rutgers, the State university, has many more applications for enrollment in engineering than it can accommodate because of its facilities. Even at Penn State, Mr. Van Zandt, I noticed the other day that they had 10,000 applicants for the freshman class last fall and they admitted 2,000 students. They turned down 8 students for every 2 that they take in. That is primarily due to facilities.

Representative PRICE. Let me ask you this question: Do you agree with most of the testimony given here today and yesterday that there is

a shortage now and possibly will be for the next few years in the turning out of scientific and engineering manpower?

Mr. THACKREY. I do, and I also agree with the statement that there are shortages in practically every field. We are just about as much, or maybe even more worried, about shortages in biological sciences and agriculture as we are in engineering. Enrollments there are not going up as fast as they are in engineering.

Representative PRICE. If you were asked for a suggestion or a recommendation of what to do to help to solve the problem, what would be your first recommendation and what would you think of first?

Mr. THACKREY. I think my first suggestion would be helping institutions expand their facilities and keep their staffs.

Representative DURHAM. Right at that point, if you will yield. Could you possibly give us an estimate of students turned down last year of the land-grant colleges that were making applications for these courses?

Mr. THACKREY. It would take quite a little while to do it. We did a little survey of our engineering schools and it was incomplete. We only got 18 replies, and we got about 4 which said they had turned down substantial numbers of students. That is not true, generally, in the Midwest, but it is true in the Northeast.

Representative DURHAM. If it is true like you indicate, that one college you mentioned, the fact is it is not the lack of desire to take these courses because I imagine he would not have made application if he was not qualified, but it is lack of facilities?

Mr. THACKREY. That is not true in Illinois or Indiana, but it is true in some States.

Representative VAN ZANDT. Is it not true that colleges that do have facilities still turn down a lot of applicants?

Mr. THACKREY. They turn down some for lack of qualification; yes.

Representative VAN ZANDT. In addition they have restrictions on the number of school students enrolled from outside the State.

Representative DURHAM. You mean the teaching personnel as well as the facilities?

Mr. THACKREY. I mean both; yes.

Representative DURHAM. Which ones would you classify as the most stringent?

Mr. THACKREY. Our engineering survey stressed both of them.

Representative VAN ZANDT. There is a point I brought up here this morning that concerns the employment of the faculty members in this field. That is as consultants. I am concerned as to what we are doing to the members of the faculty.

At Penn State they have a group of scientists and industry is employing these faculty members as consultants. How far can we go in that field until we destroy their value as a faculty member?

Mr. THACKREY. That is a problem for every college president in an institution like Penn State with a well qualified staff. The same thing is true of medical schools. There are two other brief comments that I would like to make.

First, I would like to endorse everything Dr. Brownell has said. We cannot get the statistics that we really need from the Office of Education.

Representative DURHAM. You get all of the information that they have from the Office of Education?

Mr. THACKREY. A great many other organizations do research and it is valuable, but their figures are dependable and official.

Representative PRICE. That type of service would be valuable to you?

Mr. THACKREY. Very valuable to us, and particularly, also, this coordinating service which was specifically turned down by the House committee, the service for coordinating and assembling the results of research in all parts of the country. You cannot get that any place now.

Representative PRICE. Do universities call upon the Office of Education for that information?

Mr. THACKREY. My office does, and that is the only place I can turn.

Representative PRICE. Does the Office send it to the universities without request?

Mr. THACKREY. There is a great deal of information in the form of requests by people who want to know specific information, and the Office of Education is the only place you can find that out. Frequently a research man working on a problem does not know whether someone else has done it, writes me and I call the Office of Education and frequently they do not know, either, because they do not have that coordinating service.

Representative PRICE. And you have no place to go to get that information now?

Mr. THACKREY. No.

Representative PRICE. The only logical place would be the Office of Education?

Mr. THACKREY. That is right.

Another thing I might mention is the nuclear reactor program for instructional purposes, I notice that the budget of the National Science Foundation proposed to aid about three institutions and the AEC proposed to add some more. Altogether it was proposed to aid 7 or 8 with matching funds to build nuclear reactors for educational purposes. There are more institutions prepared to match those funds than there are funds provided for that purpose.

I cannot, personally, see why, if this is an important program, that the Federal Government might not supply it even to institutions which are not prepared to match the funds.

Representative PRICE. You will recall the committee's reaction to that. We sort of left the inference that we would oppose any limitation on it; if they were going into the program they should make it available to every university and not to a limited number.

Representative DURHAM. At one time we could not get them very much interested in that. Now I think that your statement is correct, that probably there is more desire to go into this program than there has been before.

Mr. THACKREY. I does involve matching the funds. You have to decide whether this is more important than books for the library.

Representative DURHAM. We did it in the State college in North Carolina.

Mr. THACKREY. But it cannot be done in all States, and you have some people in North Carolina that are more willing to give money for that kind of thing than there are in many other States.

Representative VAN ZANDT. Getting back to the shortage of facilities, what is your recommendation on that? Do you think the Federal Government should step in here to help these colleges to expand their facilities?

Mr. THACKREY. I am answering this personally and not for the association: Yes, I do. I am not sure how our presidents in general would feel about it, but I think that somebody would have to make that contribution.

Representative PRICE. I notice in your statement that you are not too enthusiastic about a scholarship program.

Mr. THACKREY. No, sir. I think that it might have a place, but I am talking about an undergraduate scholarship program. It is very difficult to work out one that does what you hope it is going to do. It may be possible to do it.

In the first place, you are always in danger of giving your scholarships to people who would go to college anyway. You might be able to avoid that by a means test or something of the sort, but in the second place you get into what should you pay the college. If you pay them their customary tuition fee and you have a big program, you tend to drive up the fees because that is the only way the institution can get revenue from those people and it exerts upward pressure on the fee structure.

Representative VAN ZANDT. What is your opinion on this present AEC program that involves 60 students, from foreign nations and the United States?

Mr. THACKREY. I am not familiar with the detail of it, but I think it is an excellent program and I am glad to see that Penn State and North Carolina State, two land-grant institutions, are helping out in that this year. I think those are the only two that have reactors for training purposes.

Representative VAN ZANDT. It seems that the program at these two institutions is just a drop in the bucket.

Mr. THACKREY. I think so.

Representative PRICE. We appreciate your fine statement, and your full statement will be inserted in the record at this point.

(The statement referred to follows:)

STATEMENT OF R. I. THACKREY

Mr. Chairman and members of the committee; my name is Russell I. Thackrey and I am executive secretary of the American Association of Land-Grant Colleges and State Universities, which includes 71 colleges and universities located in each State, Alaska, Hawaii, and Puerto Rico. The land-grant institutions comprise a national system, established following passage by the Congress in 1862 of the Morrill Land-Grant Act, designed to foster a system of colleges and universities which would emphasize the application of science to the problems of agriculture and industry.

The land-grant institutions have justified the high hopes of their founders. Today, although they enroll only about 18 percent of all United States students in higher education, they annually graduate about 38 percent of all engineers in the country, and award about the same percentage of all doctoral degrees in the physical and biological sciences.

My comments today are purely personal, and do not reflect in any way the considered policies, or proposals, of the association for which I work.

Mr. Chairman, I believe the general situation and the progress made in this country in increasing the numbers of trained personnel is better than is reflected in the excellent report made to you by the staff of the Library of Congress.

This report failed to emphasize the fact that in the past 2 or 3 years, our

college-age population has been smaller than it was in the late 1930's. In spite of this fact college enrollments in the fall of 1954 were 82.2 percent higher than they were in the fall of 1939, when there were a half-million more student in the normal "college age" population.

The report also paints a somewhat darker picture than is justified, as to trends in college enrollments in engineering and science. In the first place, its comparisons were made with the year 1950, which was an unusual year for reasons I shall comment on; and in the second place most of the studies on which it relied did not reflect certain improvements which have occurred since the studies were made. The year 1950, with which comparisons are most frequently made, represented the peak or close to the peak of the post-war veterans' enrollment and graduating class. Since the veteran students were mostly men, and the enrollments in engineering and to a lesser extent science are predominantly men, it is only natural that 1950 would show a very high proportion of students in engineering and science, and large absolute numbers because of the 4-year interruption during World War II.

Enrollment figures for the fall of 1955 indicate that the percentage of engineering students in the total college student body has risen from 8 percent in the fall of 1951, to 9 percent in the fall of 1955. Engineering enrollments have increased by 46.9 percent since 1951, while total higher education enrollment has increased only 28.6 percent, and total male enrollment only 27.6 percent. For each of the past 4 years engineering enrollments have increased at an accelerated rate, the percentage of increase being 6.6 percent for 1952, 9.5 percent for 1953, 10.9 percent for 1954, and 13.5 percent for the fall of 1955. The 13.5 percent increase in the fall of 1955 compares with an increase of 11.4 percent in the total male enrollment in college, and an increase of only 3.4 percent in the male population age 18–21. I would also point out that the engineering enrollment figures do not include students in junior colleges or liberal arts colleges who are taking curricula leading to transfer for an engineering degree. Since junior college enrollments have increased very rapidly in recent years, and many arts colleges have in that period worked out arrangements with engineering colleges for a combined degree through a cooperative program, it seems clear the above figures probably constitute an understatement of the increase in engineering enrollments.

Many suggestions have been made for Federal and other action to increase the supply of trained manpower, particularly in engineering and science. I shall comment only on those having direct application at the college and university level. One of the most frequently mentioned is a large-scale program of Federal scholarships. While scholarships have an important role to play, I have many reservations about a Federal scholarship program. One is that it would require great skill to devise a Federal program which would not result largely in subsidizing people who would go to college anyway, rather than those for whom finances are the sole barrier to college study. A second reservation is that recent surveys indicate more able students fail to go to college because they don't want to go, than because they can't afford to go. A third is that large-scale Federal scholarship programs in which the institution receives its "customary fee" tend to put pressure on the colleges to increase their fees, which increases costs for nonscholarship students and consequently the need for more scholarships. The payment by the Federal Government of the "customary fee" of an institution in connection with a scholarship program tends to penalize those institutions who have kept their fees low, either through endowment support or State and local tax support, as compared to those who charge the student for a high percentage of the cost of his education. Still another objection is that scholarships limited to students who will study science and engineering create an imbalance in our educational system and consequently in our national life. The need for trained people in all our professions is great, and no one can now predict just which field may be most critically needed 5 or 10 years from now. Language specialists may, under some conditions, be more critically needed than engineers, or trained biologists than chemists or physicists. Many young people entering college are not ready to, and should not, choose their life field of work. It would be wrong for them and wrong from the standpoint of national need, to bind them to a particular field of college specialization permanently, or cause them to face loss of their educational opportunity. Proportions of those entering science and engineering can be increased substantially by other means than undergraduate scholarships limited to certain fields.

A second suggestion that has been made is the creation of new Federal academies to train scientists and engineers. Just a hundred years ago, Mr. Chairman, this suggestion was made by Representative J. S. Morrill, of Vermont, later Senator from that State, as a means of getting trained college people to serve agriculture and industry. Mr. Morrill later changed his mind and sponsored legislation to give permanent Federal aid for the establishment of a national system of institutions under State control, the land-grant institutions. This system enrolled some 484,500 undergraduates and graduate students last fall, and the Federal Government's contribution to their instructional budget was less than 3 percent.

My point is, Mr. Chairman, that much, much more could be done by strengthening and expanding our existing system of colleges and universities than by establishing new Federal colleges and universities wholly at Federal expense for buildings, facilities, staff, operating expense, and living expenses of students. A new Federal "science and engineering academy" or even a series of them would scarcely make a noticeable contribution to an increase in the supply of scientists and engineers. In fact it is entirely conceivable that a very high percentage of its student body would be young men who would have gone to college anyway.

We do not lack colleges and universities capable of giving high quality work in science, engineering, and every other field. But some of our existing institutions are severely handicapped by lack of buildings, facilities, housing, and staff. My opinion is that helping existing institutions expand their facilities and lower their fees would make a far greater contribution at far less cost than either the establishment of new Federal institutions, or a large-scale scholarship program.

I call your attention to the fact that some of our States, including some which have fine colleges and universities and a long tradition of higher education, make it very difficult for their own young people to go to college, as compared to the situation in other States. For example the public universities of the New England area in general have limited facilities, high fees, and some of the New England states are near the bottom of the Nation in the percentage of their own young people who go to college. In a 1949–50 survey Maine, Vermont, and Rhode Island were in the lowest 12 States in the Nation in proportion of young people resident in the State attending college, in proportion to total population. The great industrial State of New Jersey, with a population of 4,835,000 in 1950, had 5,117 students enrolled in all its engineering colleges in 1954, while the great industrial State of Michigan, with a population less than 25 percent larger, had in the same year nearly 13,000 engineering students enrolled in its institutions, or more than 2½ times as many. South Dakota with 20 percent fewer people than Rhode Island, had in 1954 about 20 percent more students enrolled in its engineering schools than Rhode Island. Pennsylvania State University, which has a fine engineering school, is currently rejecting 8 out of every 10 applicants for admission.

One could cite examples from the South, Mr. Chairman, but I have purposely chosen examples from other areas to show that limitation of educational facilities, coupled with the high fees charged at public universities, are a serious and major factor in limiting the numbers of young people who get college training, particularly in engineering and the sciences where facilities are expensive.

The impact of various major Federal programs of recent years on our colleges and universities is not generally realized.

One of these is, of course, the atomic energy program. I do not need to remind this committee that appropriations for atomic energy have gone from nothing prior to World War II, to a budget estimate of $1,672 million for fiscal 1957. You know better than I the demands created by a new program of this magnitude on college and university trained personnel, on teaching staffs, on research staffs, and on research facilities. The Federal Government pays for research for which it contracts with colleges and universities, and there is a limited program of graduate fellowships federally provided. But how extensive is the Federal contribution to the cost of the facilities for undergraduate instruction of the young people needed for these programs? One case in point is the provision of nuclear reactors for research and teaching purposes. The budget request this year, as I understand it, contemplated a limited program under which National Science Foundation would, on a matching basis, help about three universities provide nuclear research facilities, and the Atomic Energy Commission might help a few more with reactors for teaching purposes.

In acting on the National Science Foundation request, the House cut this item sharply. There are already more colleges and universities which are prepared to pay half the cost of a nuclear facility than the budgeted program calls for. But why should the program be limited to those States and institutions which can pay half the cost? My home State of Kansas, for example, has about 3,600 engineering students in its public colleges and universities. Alabama has about 4,000, Oklahoma about 4,500. Each State has more pressing needs in higher education than it can currently keep up with. Is a nuclear reactor for teaching purposes more important than books for the library, a raise in salary for the faculty, an addition to the medical school, a classroom building, a decent place for students to sleep, or an agricultural research facility? If it is of great national importance, and I think it is, cannot the National Government see that the facilities are provided wherever the concentration of people to be trained is great enough to justify it?

A second related item is national defense. Research and development expenditures of the Department of Defense were $30 million in 1940, and for fiscal 1957 the budget estimates are nearly 1.5 billions. Here again the national responsibility is clear, the impact on colleges and universities great, and the Federal contribution to the cost of supplying the need is limited to payment for the facilities and staff actually used, not to the cost of the undergraduate training.

A second item under national defense is the ROTC program, which supplies most of the Reserve officers and a substantial number of the Regular officers for the armed services. A recent survey of about 350 colleges and universities having ROTC programs indicates that ROTC uses, on the equivalent of a full-size basis, more than $180 million worth of facilities in colleges and universities. The colleges pay for the construction of this space, and for its operation and maintenance. Much of it is, frankly, not as good as it should be in the interests of efficiency of this program, which in the past 5 years has furnished about 135,000 officers for the armed services. If the Federal Government would pay even half the cost of new facilities for ROTC use, it would greatly help the institutions to meet their needs in other directions.

Still a third example is the agricultural programs of the Federal Government. These employ directly large numbers of people, most of whom are trained in land-grant institutions. Certain programs, such as agricultural research and extension, are done cooperatively with the land-grant institutions. The cooperative agricultural extension program of the land-grant institutions and the Department of Agriculture, for example, involves about 13,000 persons, and cost about $112 million in fiscal 1956, of which 60 percent was paid by the States and counties, and 40 percent by the Federal Government. Total agricultural research expenditures of the land-grant institutions and the Department of Agriculture were in fiscal 1956 about $161 million. Of this amount, about half was paid for by the Federal Government, and about half by the non-Federal sources. About $58 million of the Federal contribution for agricultural research was expended directly by the Federal Government; about $25 million went as grants-in-aid to the land-grant institutions. Thus, the land-grant institutions furnished, from non-Federal sources, about $3 in research funds for every $1 received from Federal sources. They also furnished all the buildings, facilities, experimental fields, etc., for their program, including facilities for many Federal workers stationed at land-grant instiutions. The total Federal contribution to the teaching budget of the land-grant institutions, which includes many programs other than agriculture, was less than 3 percent in fiscal 1956.

A fourth major example is the field of medical research and education. Total medical research expenditures in 1940 were estimated at $45 million from all sources. In 1956, they were $240 million, of which $113 were federally financed. The House of Repersentatives has just approved an appropriation for this activity of $135.5 million for fiscal 1957. This is more than 3 times the total 1940 expenditure from all sources, and it is probable that total exepnditures for medical research next year will be at least 6 times as large as 1940. It is clear that national action has created a substantial demand on the product of colleges and universities, but there has been no corresponding national action to help meet the demand at the undergraduate level.

The field of veterinary medicine is another which is most important to the public health and welfare, very expensive to operate, but whose educational facilities and costs are provided wholly by State governments.

Still a fifth example is our important international program of technical assistance and educational exchange. This program has placed great demands on our colleges and universities: For the training of foreign nationals brought to

this country, for the release of staff members to go abroad, and for direct work abroad of staff members under a university contract with International Cooperation Administration. I am happy to note that two land-grant institutions, Pennsylvania State University and North Carolina State College, are this year furnishing part of the training program for foreign nationals under the atoms-for-peace program. Here again, the need and desire of the National Government for assistance is great, and its willingness to help pay the real cost is very limited.

I realize, Mr. Chairman, that several of the examples cited are outside the jurisdiction of this committee. However, I wished to emphasize that the impact of Federal actions on the colleges and universities is many sided, and that what is done in one area directly affects the ability of colleges and universities to carry on adequate programs in other areas. The land-grant institutions were founded by Federal action, and have worked cooperatively with the National Government in many areas for nearly 95 years. I feel sure our association would be willing to make formal and carefully considered suggestions for action to your committee, if you desire them to do so.

Representative PRICE. The committee will stand in recess until 10 o'clock tomorrow morning. We will meet in room F–82.

(Whereupon, at 5 p. m., Wednesday, April 18, 1956, the hearing was recessed to reconvene at 10 a. m., Thursday, April 19, 1956.)

SHORTAGE OF SCIENTIFIC AND ENGINEERING MANPOWER

THURSDAY, APRIL 19, 1956

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
SUBCOMMITTEE ON RESEARCH AND DEVELOPMENT,
Washington, D. C.

The subcommittee met at 10:20 a.m., pursuant to recess, in room F-82 of the Capitol, Hon. Melvin Price (chairman of the subcommittee) presiding.

Present: Representatives Price, Hinshaw, and Durham.

Present also: George E. Brown, Jr., of the staff of the Joint Committee on Atomic Energy.

Representative PRICE. The subcommittee will be in order.

Our first witness this morning will be Mr. Carter L. Burgess, Assistant Secretary of Defense for Manpower.

You may proceed, Secretary Burgess.

STATEMENTS OF CARTER BURGESS, ASSISTANT SECRETARY OF DEFENSE FOR MANPOWER; AND ALBERT KAY, DIRECTOR, OFFICE OF MANPOWER SUPPLY, DEPARTMENT OF DEFENSE

Mr. BURGESS. Mr. Chairman and distinguished members of the committee, I welcome the opportunity of appearing before this committee. I share your concern that this country must have an adequate supply of scientists, engineers, and skilled technicians. I believe that is fundamental to our continued economic health and to our national security.

My job in the Department of Defense concerns manpower, personnel, and Reserve forces. This morning I want to stress the importance of technical manpower to our defense effort, some particular problems we have in the Department of Defense, and what we are doing about them to help ourselves and to assist in the solution of the overall problem.

In this land of our, 167 million people enjoy the greatest prosperity the world has ever known. This is the same land which not so long ago was populated by 1 million fine and courageous American Indians, who nevertheless lived in almost continuous famine. I believe the critical difference is the vast expansion and development of our skills.

I am a great believer in education and training. When I think of continued progress, I think of the need to expand all our skill potentials—managerial, professional, skilled technicians. I think of skills at all levels and in all fields.

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The focus of your committee's concern today is scientific, engineering and technical manpower. Nobody needs to be told about the critical part these skills play in the maintenance of our technological supremacy. Our military effort depends to an increasingly large degree on continued progress in science and technology.

Military programs today emphasize fantastically complex weapons and countermeasure systems, missiles, advanced aircraft and ships. Department of Defense research and development expenditures will total about $1.4 billion in fiscal year 1956. This amounts to about 35 percent of the total national effort in this field.

Directly and indirectly, we are the largest employer of scientific and engineering talent. About 60 percent of our research and development is being done in industry, educational institutions, and in other nonprofit organizations outside the Department of Defense. We are, therefore, in competition with our own contractors and with everybody else for qualified scientists and engineers. And we have the same problems of recruitment and rentention confronting all employers, plus the problem of salaries which are generally lower than in industry.

I am informed by our research and development people that there is no evidence that our programs have been impeded to date. However, the specific effect of manpower shortage in creative activity is probably not measurable.

We have taken a number of steps to meet the problem of low pay. At the request of the Department of Defense and other agencies, the Civil Service Commission raised the in-hiring rates for scientists and engineers at beginning levels to the maximum possible under current law. This still leaves the Government behind most of private industry.

We also requested, with the support of the Civil Service Commission, that Congress authorize additional high level scientific positions in the Department of Defense. At present only 45 such positions are authorized under Public Law 313, 80th Congress. A bill to raise the number of these positions in the Department of Defense from 45 to 275 has been introduced in the House—H. R. 9560—and has been favorably reported by the House Post Office and Civil Service Committee.

In addition, the Department has requested that the present inadequate salary range of $10,000 to $15,000 be raised to $12,500 to $17,500 for the positions authorized under Public Law 313. This request has been incorporated in the executive pay bills, H. R. 7619 and S. 2628, now pending before the Congress.

The Department of Defense also is currently cooperating with the Civil Service Commission in a study to determine the desirability of further amending the Classification Act to permit the establishment of higher pay rates at any level, wherever necessary to meet competition from non-Federal employment. This proposal would apply both to problems of recruitment and retention.

Of course, we are making every effort to utilize, and to develop to the fullest, the skills of civilian scientists and engineers currently employed in the Department of Defense. Employees are being given training at various universities in subjects related to their work. During fiscal year 1955, approximately 5,000 engineering and scientific personnel participated in such training. Cooperative training

programs also have been instituted at a number of military installations, whereby undergraduates working for engineering degrees may alternate work at the installations with periods of college instruction.

These are some of the things we are doing to improve the career development and opportunities of our civilian scientists and engineers.

We recognize that we also have a responsibility for optimum utilization of military personnel in these specialties. Considerable progress has been made in recent years. We know that we must do an increasingly better job. In fact, we have just recently initiated a comprehensive program which is designed to do that very thing: This program will be implemented and administered by the services, under the guidance of my office.

I assure you we are moving ahead on the program. We have issued policies in support of various Hoover Commission recommendations. These should make Department of Defense careers more attractive to both civilian and military scientists and engineers. They will also promote more effective utilization of these scarce specialties.

Specifically, on the military side:

1. We are sponsoring officer augmentation legislation, which will integrate more technically skilled Reserve officers into the Regular forces.

2. We are directing the military departments to provide greater stability of assignment for military personnel in technical activities.

3. We have asked the departments to explore additional career and promotional opportunities for technically qualified officers, and

4. We are establishing a high-level committee to advise on the adequacy of compensation for technical and professional personnel.

Most of the measures I have mentioned refer to officer personnel. We also give special attention to the effective utilization of our enlisted personnel qualified in the sciences and engineering. The Army, which receives the bulk of such personnel through induction, has operated a special scientific and professional personnel utilization program for years. It has identified 5,000 professional-type positions in its laboratories and technical installations, and monitors the assignment of qualified enlisted personnel to such positions throughout their tours of duty.

The Navy, which is receiving professionally qualified personnel through its recent intake of inductees, has developed a similar program for the identification and effective utilization of these specialists.

Now, all of these matters I have covered refer to the professional level—civilian, officer and enlisted scientists and engineers in the Department of Defense. That is not the whole problem by any means.

The armed services have a particularly acute problem in the area of skilled technicians. The highly complex weapons made available by American science and industry will prove no more effective than the capability of our fighting men to maintain and operate them under combat conditions.

Military requirements for highly skilled technicians are increasing rapidly. About 40 percent of our enlisted personnel are now needed for a wide range of technical or skilled jobs, as compared to about 33 percent in World War II. The soldier-technicians, the men responsible for keeping our aircraft in flying order and our complex electronic

equipment functioning, have become one of the most vital links in our national defense.

Many of these technical jobs require long periods of training and experience. In some of our more complex skills, such as electronics and aircraft maintenance, more than 2 years of training and service are required before a young man can approach a journeyman's level of proficiency. Additional years are required before he can be considered a qualified senior technician. It is therefore essential that these key jobs be staffed by a stable and highly qualified corps of career personnel.

As against these expanding needs for technical manpower our available resources of qualified career technicians are far too low. This is due mainly to the very high rates of turnover in these technical skills. In fiscal year 1955, electronic technicians completing an initial term of enlistment, reenlisted at a rate of only 6.9 percent—less than one-half the rate for all first-term personnel. Reenlistment rates were also alarmingly low in other technical skills such as armament maintenance, communications and aircraft maintenance.

The need to train replacements for these large numbers of personnel has imposed a heavy burden upon the services both in terms of cost and combat effectiveness. As Secretary Wilson has said in his letter to the President on our career incentive program:

> The loss of trained personnel continues to be the most extravagant, expensive and disruptive obstacle to the strengthening of our Armed Forces today.

The situation among enlisted technicians is also paralleled by high rates of turnover among junior officers. Retention rates among ROTC officers completing an initial tour of duty have been particularly low among officers in scientific and technical specialties such as medical, electronics, and certain engineering fields.

In order to stem this high turnover, the President proposed a number of legislative measures to the Congress in January of last year. These included more adequate medical care for dependents, more and better housing, improved survivor benefits, and selective adjustments in military pay and allowances.

Only one of these recommended measures, the Career Incentive Act of 1955, was enacted into law. The resulting increases in military pay and allowances, together with the increased reenlistment bonus authorized a year earlier, have had a stimulating effect on our over-all reenlistment rates. However, we believe that this is just a beginning.

In order to consolidate the gains to date, and—in particular—to increase the quality of our career force, the President addressed identical letters to the Senate and the House last week, urging favorable action on the balance of our legislative program to increase the career attractiveness of military service.

I want to turn now to some radical improvements we have made in our Reserve programs which will assist in conserving the Nation's scarce supply of scientists, engineers, and skilled technicians. The Department of Defense and the executive branch sponsored several measures, subsequently enacted in the Reserve Forces Act of 1955, which are directly responsive to the problem. They are (1) the special enlistment program for critically skilled persons; (2) screening of the Ready Reserve; and (3) special procedures for calling up the Standby Reserve.

Under the special enlistment program, certain critically skilled persons employed in defense-supporting industry or research may enlist in the Ready Reserve for 8 years. They serve on active duty for training for only 6 months, and fulfill the remainder of their obligation in the Reserve. Essential industry thus loses their services for only 6 months rather than 24 months. Further benefit may accrue as a result of the second feature—namely, the screening of the Ready Reserve.

Screening is a continuous peacetime program for providing a Ready Reserve that will actually be available for activation in the early phases of a mobilization. One of its primary purposes is to assure that Ready Reserve requirements can be met in a mobilization without seriously impairing the effectiveness of the essential civil economy.

The screening program will insure that persons with scientific, engineering, or other critical civilian skills will be retained in the Ready Reserve only to the extent that requirements exist for their skills. With certain minimum necessary exceptions, all such persons who are in excess of Ready Reserve requirements for their skills will be transferred to the Standby Reserve.

By being placed in the Standby Reserve, the critical specialist will be subject to call to active duty only in the later stages of a mobilization. He therefore remains in industry and research during the highly important industrial conversion period. Furthermore, whether he is eventually callable is subject to a finding of availability by the Selective Service System. This determination will take into consideration the individual's importance to essential civilian activity at the time of call-up. This is the third feature of the Reserve Forces Act of 1955 having a direct bearing on the conservation of scientific and other technological manpower.

The special 6 months program is now in operation. Selections of qualified individuals are being made by local Selective Service boards, subject to the usual appeals system. The screening process is about to begin. The implementing Executive order, directives, and regulations covering this detailed operation required extensive coordination with other Government agencies, professional societies, industry, and other groups.

It is my firm conviction that these measures will promote the effective utilization of young men of military age who have critical civilian skills—in the Armed Forces and in essential industry and research. And they will do so within a pattern of equity which will be generally acceptable.

In the way of final observations, I think you will agree from what I have said, that we are making considerable progress in meeting our problems. I think you will agree also that we are doing our share in promoting optimism utilization of our limited national supply of scientists and engineers. However, I believe the basic solution to the overall problem lies in increasing the supply and quality in the first instance. That is the job of our civilian educational system, because that is where these skills are produced.

Some time ago I had the privilege of serving on a special interdepartmental committee which studied the overall problem. This committee was chaired by the Director of ODM, and included the Secretaries of Commerce, Labor, and HEW, the chairman of the AEC, and the Director of the NSF.

At the recommendation of the special committee, the President established a National Committee for the Development of Scientists and Engineers on April 3, 1956. The National Committee is comprised of representatives of major citizens organizations. The objective is to develop a grass-roots campaign through these organizations, so that we will get the action that is needed in each of our communities. I am sure Dr. Flemming has described this activity in some detail.

My own feeling is that the principal area needing improvement lies in the better identification, motivation, and preparation of young people of talent at the high-school level. This country has thousands of local school boards and authorities which control the high-school curricula, and decide such questions as whether there will be separate science teachers, proper salary levels, et cetera. Affirmative actions on these matters will depend to a very large degree on developing a public awareness and demand for them at the local level.

There are also many things that industry and other groups can do which will be of positive assistance. I believe the National Committee will be an effective medium for stimulating and coordinating the constructive action of all these groups. For that reason, I think the appointment of the National Committee by the President represents an extremely practical approach. I am convinced that when the American people are told the full story, they will take the action that is needed.

Thank you, sir.

Representative PRICE. Mr. Secretary, is there any place within the Defense Establishment now where the shortage of engineers has adversely affected the program?

Mr. BURGESS. Well, I think that we have shortages, of course, in our enlisted and officer situations, Mr. Chairman, which I do not believe have had a crippling effect, but they certainly have engaged us in a lot of extra effort in recruitment, in training and retraining and reclassification that could have been expended in getting along with other things, if we had not had to take on those tasks.

I believe in the civilian field we have not been seriously impeded. In the officer and enlisted field of the Military Forces, we could have gotton a lot more done if we had not had these high loss-rates.

Representative PRICE. What is your situation in regard to being able to meet the requirements for scientists?

Mr. BURGESS. For what, sir?

Representative PRICE. Scientists and chemical engineers, who would fit into your expanding picture on your reactor program, for instance, the reactor program that the Army is getting into at Fort Belvoir and the package deal on the reactor? How are you equipped to meet the expansion of that program?

Mr. BURGESS. I am not familiar with the details of that particular program, Mr. Chairman, but I think there are a variety of ways of meeting requirements; that is, by contract employment of outside groups, by direct-hire in our scientific and engineering civilian grades and by assignment of highly qualified people who are in the officer and enlisted establishment. I think we approach this from three sides when we get into these types of programs. We try to break it down, so that we can use these three groups to the very best advantage.

Is that about right, Al?

Mr. KAY. That is our general approach. I do not know the details of the particular Fort Belvoir program.

Mr. BURGESS. We bring these three groups to bear on a major program of the kind that you mention.

Representative PRICE. Has the shortage of scientific, engineering, and technical manpower been such up to now that it has been the cause of great concern to the Defense Establishment?

Mr. BURGESS. Yes, sir, it is. I do not know of any element, Mr. Chairman, in our overall manpower and personnel efforts that receives more attention than this ability to attract, retain and properly utilize the overall scientific and research group. It has been a problem, because, I think that you will recognize that in the development of the Military over the years, we spent a great deal of time in developing personnel and pay systems that had as their major objective the development of leadership. Today we not only have to continue the good programs which are directed at developing leadership, but we now have to adjust to the arrival of the technician and the scientist in their new and increasingly important roles. We are trying to go about that in a very sensible and reasonable way, so that we do not upset the time-developed programs of leadership development. We must establish proper programs for technicians and scientific personnel within an effective overall pattern.

Representative PRICE. This is geared more or less right now to what we call a peacetime period, is it not?

Mr. BURGESS. Yes, sir.

Representative PRICE. And it will become more active and more serious if we get into a period of mobilization.

Mr. BURGESS. Very much so, sir. And I think we have to move posthaste while we are in these times, to lay out the very best programs and procedures that can be found.

I made quite a point of this in my appearance before the House Appropriations Committee hearings on the Defense Department. I indicated that probably one of the major bills we would bring to the Congress next year will be a bill providing the proper personnel procedures and pay plans for getting the scientific and technical personnel aspect in parallel with our leadership plan. It takes longer, as you know, to develop a leader. A technician and a scientist, once he has gotten his skill, has it. He may get there a lot sooner than the leader gets there. So we have to adjust for that.

Representative PRICE. But your concern over the scientific and engineering manpower question is not only military, but it is also your civilian?

Mr. BURGESS. Yes, both come in.

Representative PRICE. Now the Atomic Energy Commission stated before our committee day before yesterday that they had an annual requirement of about 2,000 reactor engineers and technicians and so forth, and of that number they were able to recruit only about 500 per year. They had a requirement of 2,000 a year and were recruiting about 500 a year. So they are getting only about 25 percent of those types of engineers that they require.

Do you have any numerical requirements for civilian scientific and engineering personnel per year on an annual basis, in keeping with your program?

Mr. KAY. We do not have it here, sir, but I may remark, if I may, on that particular problem of nuclear engineers, that I would think that everybody is having difficulty because that is a rather new specialty. I think the AEC and various other people are responsive to it. There have been special schools set up, the Oak Ridge Institute being one of them. I understand that AEC is financing programs under which they bring engineering professors from the colleges in for the summer, and give them special courses in these new developments, so that they will be in a better position to instruct and motivate students in this field. In other words, I think there you have a rather special application, and probably a very special need that has to be met in a special way.

Representative PRICE. Yes. I was thinking of that special need.

But the point I was trying to get at was whether you had a numerical requirement of scientific and engineering personnel per year in the Defense Establishment, and what your success was in recruiting the number that you needed in all different fields, as long as they are technical manpower.

Mr. KAY. No, we do not have that at hand. Our largest group is the civilian group, that is the direct hire civilian group. To a lesser degree that type of work is done by the military. I cannot give you the numerical shortage figure. I think it is a very difficult thing to come by. I think we have had the same experience as industry in this respect. Very often a job does not show up as a shortage. You just make-do, and put a less qualified man in it. It is a very hard thing to get at, just what is lost thereby, in that type of creative activity.

Mr. BURGESS. Mr. Chairman, we can attempt to make the calculation for you and get it in the record.

(The information referred to follows:)

1. Scientific and engineering personnel strengths and shortages at Redstone Arsenal are indicated below. The Army conducts two major research and development activities at Redstone. The first is the arsenal proper, and the second is the Army Ballistics Mission Agency. The figures, which cover both activities, indicate the large number of unfilled engineering and scientific positions relative to current employment.

Total scientific and professional personnel at work at Redstone Arsenal, Huntsville, Ala., as of Apr. 1, 1956

	Total at Redstone	Army Ballistics Missile Agency	Arsenal
Total professional	1,300	651	649
Total military	374	107	267
Officer	161	53	108
Scientific and professional (enlisted)	213	114	99
Total civilian	926	484	442
Engineers	692	362	330
Scientists	234	122	112

Total scientific and professional personnel shortages of Redstone Arsenal, Huntsville, Ala., as of Apr. 1, 1956

	Total at Redstone	Army Ballistics Missile Agency	Arsenal
Total professional	723	618	105
Total military	60	45	15
Officer	3	1	2
Scientific and professional (enlisted)	57	44	13
Total civilian	663	573	90
Engineers	493	424	69
Scientists	170	149	21

2. The following tabulation covers shortages of civilian scientists and engineers at all Department of Defense research and development-type activities, including arsenals, etc. Navy and Air Force data are as of April 1, 1956. While Army data are as of December 31, 1955, shortages have continued large since that time.

Sample studies indicate that the primary reason for failure to attract the needed personnel is the relatively low salary level for Federal employees; 56 percent of the scientists and engineers who declined an appointment with the Navy gave "low salary" as their reason. The Air Force listed 310 out of 538 candidates declining because of insufficient salary.

Shortages of civilian scientists and engineers at Department of Defense Research and Development-type activities

	Total	Army [1]	Navy [2]	Air Force [2]
Total	2,977	901	1,538	538
Physical scientists	738	122	497	119
Engineers	2,239	779	1,041	419

[1] As of Dec. 31, 1955.
[2] As of Apr. 1, 1956.

3. No figures have been compiled as to the average age of enlistees into the 6-months training program for persons between 17 and 18½. However, it appears likely that the average would be about 18, taking into consideration that that is the average age of high school completion for males, and taking into consideration several other counter-balancing factors.

Mr. BURGESS. The problem in our office is to make certain that we have the proper manpower procedures and policies. It is also our job to make certain that we have the positions and the salary ranges that will keep us in a fairly competitive position.

As I say, part of our requirements can be offset by the utilization of contractor employment.

Representative PRICE. I was thinking more of the requirement you have to staff your facilities, such as your proving ground facilities, your places like Edgewood Arsenal, your chemical labs, and different facilities where you require this scientific and various types of engineering training.

Mr. BURGESS. I am sure we can get you a tabulation of that, Mr. Chairman.

Representative PRICE. Offhand, what has been your experience there? Are you having difficulty there?

Mr. KAY. I believe they are having difficulty.

Representative PRICE. I would like to have the figures, but right now I was just wondering whether or not you are having difficulty.

Mr. BURGESS. I can articulate the problems we are having in our reenlistment, as well as anything.

Before the Congress passed the reenlistment bonus and before the Congress passed the Career Incentive Act, our reenlistment rate for specialists in the category of technical personnel was running at a small figure. That was particularly true up to fiscal year 1955.

Where we would like to have reenlistment rates in those specialties run up to 50 percent, it was somewhere down as low as 8 and 9 percent.

With the passage of those two bills, we have noticed in the first quarter of fiscal 1956 a rather dramatic increase in reenlistments. It is dramatic in percent of increases but the total rate is still low.

We feel quite definitely that we have to make still further improvements in retention of our scientific and technically-trained officer and enlisted personnel.

Representative PRICE. Even before, the military, the Armed Forces, did a great amount of basic research in many items that are used in civilian life.

Mr. BURGESS. Yes—and they still do.

Representative PRICE. For instance, the Quartermaster Corps, and almost every branch of the armed services, have some connection with basic research.

Is there any indication that these programs are being or might be adversely affected by this growing shortage of scientific and technical manpower?

Mr. BURGESS. Mr. Chairman, I would say that it would be adverse in our military field if we do not have some further increases, very substantial increases, in our retention rates of technically trained officers and enlisted personnel.

That is particularly true, I believe, in the case of the Air Force and the Navy. If we do not have an improvement on the retention side there, it could lead to adverse effects.

Representative PRICE. You mentioned in your statement about the difficulty in the retention of scientific manpower in the officer grades and probably enlisted grades, too, among technicians, including medical and other specialized grades, I know the figure is going to be very low, but do you have any estimate of percentage of those types of officers who remain in the service?

Mr. KAY. There is a figure.

Representative PRICE. I am not talking about the regulars.

Mr. BURGESS. I know.

Representative PRICE. I am talking about those who come in there.

Mr. KAY. Via ROTC.

Mr. BURGESS. We have a very high loss in the junior officer groups. I do not know whether you have the specific figures, Al?

Mr. KAY. I think it is safe to say that the retention rate among those groups after the initial term of duty is almost negligible, that is, in respect to those ROTC people who come in with professional-level scientific skills.

Mr. BURGESS. What we are trying to do in that particular situation, Mr. Chairman, is this:

We have a fairly sizable augmentation bill before the Congress now. You take in the case of the Air Force, only 17 percent of the Air Force

fficers are regular officers. In other words, our total officer requirement in the Air Force, of that number, only 17 percent have regular tatus.

We have a bill now before the Congress that would give us the uthority to take that up to 50 percent, and make that a ceiling.

We have every belief that if we could give regular officer status to hese men, we would have an increasingly better opportunity to hold nto the better men.

In the case of the Army, that figure is running around 26 percent, nd our augmentation program there would permit a 50 percent eiling, similar to that which the Navy and the Marine Corps have.

We feel through that regular status that we would have a better hance to hold on to them.

We feel in the technical and scientific officer grades that we have to mprove our rotation policies and keep these men no longer assignments and not be moving them around. That, too, is a detriment to ur retention.

We think also that we have to consider the rank and salary of the nen in these technical jobs. The Advisory Committee we are establishing will prepare us for whatever legislation may be necessary on hat.

We feel through those three efforts that we will have a better opportunity to hold on to more of the people that come to us with advanced raining and education, and also those to whom we give this very xpensive training.

I think also that industry could very well do more training at the killed technician level. We are doing more than our share.

Representative PRICE. Mr. Hinshaw.

Representative HINSHAW. I am glad to have this opportunity to alk with Mr. Burgess, because I think that we are likely to look at his problem from the standpoint of Government and not so much rom the standpoint of the young man himself.

After all, he is the fellow who is going to decide whether he reenlists r whatever it might be.

Now, I think it is worth while to go through the problems that eset the young man who desires to have an engineering or technical r a scientific education and who is capable of receiving and benefiting rom that education.

I am a civil engineer, and I think I can speak with some degree f authority, because there is a great university right in my hometown, California Institute of Technology, and I am very closely ssociated with a number of other institutions in California.

I would like, if I may, to outline against the problem that besets he young man.

He comes up to graduation from high school. Generally, by the ime that he is in his senior year in high school or prep school he has ndicated his keenness and his aptitude for such training.

He has two choices. He can either volunteer for the draft immediately, thereby postponing his future education by 2 years, or he can o along into college and trust that his abilities will keep him above raft status.

I just forget the proportions now that we weeded out in the freshman and sophomore years, but it is a fairly high proportion.

But, let us say that he escapes, because of his abilities.

He comes into a college and it may or may not have an ROTC course in it. The chances are, if it is a large institution that it does have an ROTC course. Let us say he applies for ROTC. It can be Army, Air Force, or Navy ROTC, but he must pass a physical examination in order to qualify.

Peculiarly enough, brains are not measured by physical standards. As a matter of fact, a man might have great brain power and yet not have 20/20 eyesight.

Unless he is able to pass West Point physical standards he cannot enter the ROTC except in a few very rare instances, such as the one wherein the Air Force ROTC, I think, something like 2 percent of the students are accepted with below physical standards, below that standard for Air Force officers.

He can have eyesight of 20/50, I believe, but that has nothing to do with his abilities, nor his aptitude, but it has to do with whether or not he is permitted to enter the ROTC.

In other words, the ROTC is a thing that selects students for entrance by physical standards and not by mental standards.

Supposing he is able to meet the ROTC standards and he goes through junior and senior ROTC. At that point, being say in the high 10 percent of his class, having made Phi Beta Kappa or Pi Beta Phi, or whatever, he must nevertheless separate himself from the university at the end of his scholastic career for a bachelor's degree and serve 2 years as a second lieutenant or an ensign in the Navy, thereby breaking off his education.

Now, point 1 with me is, even in spite of the fact that he graduated in the ROTC, senior ROTC, and was entitled to an appointment as a second lieutenant or an ensign, being in that mental ability classification which is necessary for continuance into graduate school, if he were permitted to proceed at once to the graduate school instead of serving his Reserve officer period, it would very materially aid him, because a 2-year hiatus at that point is a very difficult thing to recover, both from the standpoint of the ability to study and from the fact that at the end of the period he is thinking about other things, getting married, getting a job, whatever. The chances are that he drifts away from the scientific pursuit, that can be carried right through to a doctorate, a Ph. D.

When he achieves these other degrees, I think that if he were considered to be somewhat in the status of a graduate doctor of medicine, then having served an internship, he should be entitled to a promotion in the ROTC for having gone ahead and done that thing. That would achieve a lot more doctorates, a lot more masters of science. Perhaps I am wrong, but I think it is true, and that can be measured by any standard that you want.

Then, let us take the other fellow, the fellow that was not able to take the ROTC training, either because of physical fault or because there was no ROTC available.

His position is rather sad, especially if he has less eyesight than the requirements, or some other physical disability that does not preclude his service in the Armed Forces, but does preclude his achieving officer status.

I wish you would, if you can, explain to me why it is that a man who achieves a bachelor's degree in engineering and is subject to induction in the Armed Forces, should be any less worthy of a commission than

a man who achieves a bachelor's degree but has the physical qualifications to enter officer candidates' school, or go directly into the service as a second lieutenant.

Now, I say that because I think that is vital and important. If you want brains, there is an opportunity to get some. If all you want is bodies, well, of course, that is different.

But I do not see that there is any difference between the two men at all, if they are able mentally and qualified for the lowest physical standard that will cause their induction into the service.

It is a rather degrading thing for a young man to find that he misses those physical standards which allow the man on his right to serve as a second lieutenant, with the same education, the same abilities and all, and he, on the other hand, must serve as a private. It is rather difficult.

Then I want to differentiate between the services. Let us take the Army, and Air Force, the Marine Corps, and the Navy—and the scientist student.

Obviously, the scientist student or the engineering student is going to have difficulty in getting into the Navy or the Air Force ROTC because his chances of being perfect physically—which is required—are very low indeed.

On the other hand, he may have great mental ability.

The duties that are required in the Navy and in the Air Force are not solely flying duty, not solely in deck service, in the Navy. They are not solely in that.

As a matter of fact, ships must be operated. There is a great crew below decks, an engineering crew. There is a great crew of armorers, who handle such things as atomic weapons, on a carrier, and all of that sort of thing.

In the Air Force there is a great crew that is required for maintenance, for operations, who are not flight personnel, yet the qualifications to become an ROTC student are such that almost nobody can get into Air Force ROTC unless he is perfect physically.

Yet there are lots of others capable. I think that the physical qualifications should be lowered, that is, the physical qualifications should be lowered for a college student, so that he is able to achieve a commission, and serve in some capacity as an officer if he achieves a bachelor's degree or higher.

Then my other recommendation was that his service requirement be postponed if he goes on to achieve a graduate degree.

Mr. BURGESS. Constructive service.

Representative HINSHAW. Pardon?

Mr. BURGESS. Constructive service. Give him credit for that service, so when he gets in he is not behind the man who did not take that and did go in and got promoted in the meantime.

Representative HINSHAW. Yes. He goes on and studies.

Mr. BURGESS. That is right.

Representative HINSHAW. You send officers of the Army to MIT, California Tech, and other places, to get masters' degrees.

Mr. BURGESS. And they get paid for going to school.

Representative HINSHAW. And they get paid for going to school, and this man who wants to go to school and wants to pay for it himself, or receives a scholarship, is unable to do so. You see? That is

one reason they are not going into the service if they can help it, while they are seeking credits to allow them to get and achieve these master degrees and Ph. D. degrees, if they are competent to achieve them.

I am talking to you solely from the attitude of the young man, not from the needs of the service, because the young man, if he is recognized for his needs and his wants, I think, will fill the services' needs, without very much attention further than that which is already given.

Now, maybe I am wrong. I would like to have the comments of the Department.

Mr. BURGESS. Are you ready for me to try to give those, Mr. Congressman?

Representative HINSHAW. Yes. I am sorry that I have taken so much time.

Mr. BURGESS. Yes, sir. I followed you very closely, sir. I can see the wisdom of many of the points that you make. I hope to some degree we are in the midst of anticipating them, and also, maybe have already made some corrections, and there are some corrections to follow.

I think in tracing the young man you traced at the beginning of your comments, that you may have overlooked one other possibility which that young man has, without reference to eyesight. We will get into that just a little bit later.

I think the law, Mr. Congressman, that you gave us last year, offers him a much wider degree of choice than he had prior to the enactment last year of the Reserve Forces Act of 1955. The young man between 17 and 18½ years of age could have applied for one of these vacancies in the 6 months' program. Following completion of high school, he takes his 6 months of active duty for training and gets his military service, as far as active duty is concerned, behind him. He continues on in the Reserve while he is in college, and there is nothing to prevent him from shifting over to ROTC if he wants to. A good many of the young men are doing that, Mr. Congressman. I know that is not the complete answer, but that is one answer.

If there is another avenue for the man you traced for us, and I believe I am correct on this—Mr. Kay, you correct me if I am not. I think that we are permitting some of those young men in ROTC, who graduated from their undergraduate courses, to go on with their postgraduate work. If they go into postgraduate school, we defer their call to duty, so they can continue their education. That may not be true of lawyers or some of the groups that we may be pretty much ahead on, but I am sure that there would be a deferment for the man to finish postgraduate education for certain professions in national short-supply.

Another avenue which will minimize interruption of postgraduate work, Mr. Congressman, is that in the future the man may be considered for 6 months of duty. If he is Army ROTC he may well be considered for 6 months of active duty, rather than the regular 2-year minimum.

Representative HINSHAW. This is, providing he has a commission.

Mr. BURGESS. Sir?

Representative HINSHAW. With a commission?

Mr. BURGESS. Yes. After commissioning, he serves 6 months' active duty for training as an officer, and 7½ years in the Reserve. Dur-

ing the latter period, he can pursue postgraduate work or go into the industrial world.

Mr. KAY. That presently applies to certain Army ROTC's.

Mr. BURGESS. Another opportunity applies to the man who did not take either the 6 months' course or the ROTC course. I mean the man who went through college under the deferment plan, finished his postgraduate work in a cultural profession, and went to work in cultural defense-supporting industry or research. He comes in under the 6 months' program rather than the 2-year induction plan.

Representative HINSHAW. There is no certainty to it. Certainty is one thing that a boy's father—such as myself—and the boy himself, if you place yourself in his position for a few minutes, absolutely needs in this day and age of uncertainties of tremendous magnitude. That is one of the most important things that I think there is in character building, you might say, in the juvenile problem area of today, and that is, the uncertainty of things.

Mr. BURGESS. Mr. Congressman, we will never be able to solve completely 100 percent the uncertainty problem. But I give you my word, sir, I think we certainly helped a lot.

I think the program you enacted here last year widened the range of choice, and certainly developed a more accommodating approach than we had previous to that time.

Now, to the degree that we can get closer to certainty, I am all for it, and nobody would ever like to see young men certain more than I.

I was very pleased the other night when I was at Georgetown University to hear one of their high officials talk to a family group up there. In fact, he said these men would make better students of Georgetown University; the man who either got into the 6 months' program and got the uncertainty behind him by that program before coming to Georgetown; or the young man that lined up in the ROTC program. He said that if the man did 1 of those 2 things he was a much more certain student than the young man that came there and alined himself with neither one, and worried as to what was going to happen to him the minute he graduated.

That encouraged me somewhat on the progress we have made.

Representative HINSHAW. On this 17-year-old fellow that is given a choice into the 6 months' program, what degree of selectivity is there of the 17-year-old, or is it by application.

Mr. BURGESS. What he does, Mr. Congressman, is, he goes to a Reserve unit and offers himself for enlistment, and right now the chances are pretty good that he is going to get in, because we have a lot of vacancies, sir.

Representative HINSHAW. You may have a lot of vacancies, but I think it has a lot to do with this training program.

Here is a young man in Cal Tech, let us say, or about to enter Cal Tech, and he enters some Reserve program. He has to spend a good deal of time in that Reserve program; does he not?

Mr. BURGESS. At most, Mr. Congressman—and I do not know of any program that demands full attendance—it is 1 night a week and 2 weeks in the summertime, and most of our programs are trying to trend toward the weekend program, which would even eliminate that 1 evening a week, sir.

Representative HINSHAW. Yes.

Mr. BURGESS. And we do not demand 100 percent attendance there.

Representative HINSHAW. If he is not going into it fully, you can find out why by asking the boys. They do not like to give up their weekends, either.

Mr. BURGESS. Well, Mr. Congressman, we have to make a lot of sacrifices, and I do not think there is any indication that we could give to the Communists that would have more meaning to them than to have a full reaction to these various types of programs. To me that would indicate that we really intend to be strong.

When a young man makes a move, it is not only the young man who makes the move, but it is also his church, the community, his home, and the industrial life of the surroundings from which he came. It is an indication that everybody is working in the right direction.

Representative HINSHAW. Yes; it is an indication that everybody is working in the right direction. But they are taking a young man and saying, "You can enlist and become a private, first class, graduate as a doctor of philosophy, and become a private, first class.

Mr. BURGESS. There is nothing that says he cannot be eligible for Officer Candidate School.

Representative HINSHAW. What happens, he is picked as a platoon leader, and is sent out with the Infantry, and not connected with a scientific corps.

Mr. BURGESS. I do not agree with you there, sir. I think he may have to take certain basic training, but I think his specialty is soon decided, and he is soon put in a right position.

You take this 6-month program, sir. I spent a lot of time talking to many of these boys. We give them 4 months' basic training in the case of the Army, and then they go into Signal, Intelligence, and there are a great many other opportunities that are developed to fit their desires and their abilities. We make some mistakes—I know that.

Representative HINSHAW. I want to just put into the record two letters.

This is a letter from Mrs. M. R. Malcolm, concerning her son.

After the first paragraph, she says:

Our youngest son, Marcy R. Malcolm, Jr., was in his third year at California Institute of Technology, Pasadena, majoring in physics research, was an honor student from the time he entered there, when he was drafted into the Army by the local draft board over vigorous protests of Cal Tech authorities, just a year ago. He is now stationed at Port Whittier, Alaska, having failed to secure an assignment to any school or other Army activity where his scientific training could be utilized.

I sent that on to you and this is your reply—this is a year ago:

This is in accordance with my letter of January 12, with particular reference to Pfc. Marcy R. Malcolm, Jr.

At our request, Selective Service headquarters obtained Private First Class Malcolm's file from his local board in California. Their review of the file revealed that Private First Class Malcolm had been attending the California Institute of Technology for approximately 2 years, immediately prior to his induction, after completing 2 years at Glendale Junior College.

On September 1, 1953, his local board classified him as 1–A, available for induction. It was the opinion of the Board that Private First Class Malcolm was not making satisfactory progress toward attaining his degree since it appeared that the total period of time he would require to obtain his dgeree would be in excess of that normally required. This additional time would have been required because the California Institute of Technology apparently did not accept many of Private First Class Malcolm's Glendale credits.

Private First Class Malcolm appealed the decision. The appeal board upheld the decision of the local board by unanimous vote.

Accordingly, he was inducted on January 4, 1954.

Private First Class Malcolm was found not qualified to participate in the Army's scientific and professional personnel program, since that program is limited to those persons who have certain college degrees or combinations of degrees and experience. His primary military occupational specialty is that of administrative clerk, with a present assignment as a personnel specialist, on duty in Alaska.

Private First Class Malcolm is due to be returned to the zone of the interior in December 1955.

I trust this information will assist you in replying to your constituent. If I can be of furher service, do not hesitate to call upon me.

CARTER L. BURGESS.

Now, it must be understood that, in the first place, anybody who can get into Cal Tech is good. They take about 1 out of 10 applicants. It is similar to MIT in that respect. If he was able to complete 2 years of studies as an honor student, I do not think there is much question but the boy had great brains.

Yet he is taken out of it by the local draft board because they were searching for people who might be qualified for their purposes, and taken out of college and sent to Alaska.

It is all right—a lot of other kids do that—but there, in my opinion, and I am sure in yours, is a great waste of qualified scientific aptitude.

Can you think of anything sillier than to put him in as an administrative clerk when he is in his third year in Cal Tech and is taken out?

Mr. BURGESS. Well, sir, I am not the developer of the Army's specialty selection system, but I do think that letter indicates to me—and I am sure that you may not agree with me on this—but I think the Army has done everything in its power to find out what this man's particular specialty is, on the basis of all the people that they try to grade and get in the right job.

I do not know too many of the other facts about the thing, but that is what the tests showed and that is where the man was assigned.

I would feel a lot worse about this individual, this particular man, if he had been put in other jobs that I would consider far from the utilization made on this personnel job.

Representative HINSHAW. The man is a physicist.

Mr. BURGESS. He is not a physicist, sir, at 2 years, would you consider?

Representative HINSHAW. Two years of physics in Cal Tech is the equivalent of the ordinary university course leading to a bachelor of science degree, because it just about requires that to get in to Cal Tech. It would be a graduate degree in any place else. You try to send one boy to Cal Tech or MIT and see where they grade in. It is really terrific.

Why would not the man be better off, for example if he has got to be taken—I do not think he should be taken, I think he should be permitted to complete his course, especially he, being an honor student, and with 1 year and a fraction to go. But he is taken right out because at that late date they found out that it would require him a little longer to complete the course, maybe a few months, than the normal person. But even at that there is an opportunity to send the guy to Sandia, or a place of that sort, where his talents might be utilized, instead of an administrative in Alaska, or an administrative clerk anywhere else.

Mr. BURGESS. Do you know any of the facts on this, Mr. Kay?

Mr. KAY. Mr. Congressman, I think you have a problem here, and this man has to be measured up against all the other men who come in.

Now, in the Army specialized personnel program, they have requirements or, at that time they had requirements, that people had to have masters degrees in some of these fields.

Representative HINSHAW. To be a private first class, an MOS of SPP—I understand that. How ridiculous that is.

Mr. KAY. Mr. Congressman, there are two points there. The man is measured up with all of the other people that might qualify for the position. The point is he was at that time measured against people with masters degrees in physics.

The other point, as to why he was used as a private first class, I think the general thought there is this. If the man chooses to go to Officer Candidate School and thereby agrees to stay on longer, we would love to have him. These young officers are precisely the people that we have a negligible reenlistment on.

Representative HINSHAW. Exactly; they do not want to stay in longer.

Mr. KAY. We would love to have them, if they want to stay.

Representative HINSHAW. You do not give them a chance to do what they are qualified to do.

Mr. KAY. They have the chance. I think, myself, that people in these advanced professional specialties that you are talking about, as a generality, prefer careers in civilian life, in universities, or in industry. They come into service for the shortest time they possibly can.

That is their right. Within that, we try to do the best we can for the man and for the country, and for the Army. If he qualifies, we most certainly want him in his specialized skill. We are running short of such people.

Representative HINSHAW. You are going to run awfully short, too.

Mr. KAY. Very short.

Representative HINSHAW. As soon as they finish this 6 months out you will not get any of them.

Mr. KAY. We are also running short now because draft calls are low, and people are being discharged in these specialized skills at 400 a month. We are only picking up 200 a month. Installations, like Redstone, are feeling very hurt about it.

Representative HINSHAW. There are going to be fewer, you can count on it.

Representative PRICE. How many do you have in Redstone?

Mr. KAY. I do not know the number. There are 5,000 such people altogether that the Army monitors from Washington. No field commander can change their assignments without the Adjutant General's permission, and these are hand-tailored assignments for hand-tailored people.

Representative PRICE. Do you know how the personnel at Redstone compares, civilian with military?

Mr. KAY. No. sir; I cannot give you that.

Representative HINSHAW. Are these people at Redstone people who had the ASPP MOS?

Mr. KAY. Yes, sir. The enlisted men have.

Representative HINSHAW. How many enlisted men do you have with that ASPP MOS?

Mr. KAY. I can have that checked for you, sir.

Representative HINSHAW. How many are there in the service all around?

Mr. KAY. Altogether, at the enlisted level in the Army scientific and professional program, there are currently about 5,000 in class A assignments. Now, what has happened in the last year is this——

Representative HINSHAW. How many in class B assignments?

Mr. KAY. We have 754 in class B. A year ago we had about 2,300 in class B. What has happened is that we are losing such people faster than we are taking them in, and in a matter of months we will lose the 754 in class B and be below the 5,000 requirement in class A. Now the Army has lowered the qualification standard for these people, and transferred many people from class B to class A. Neither course is satisfactory. We are not getting as many as we really need.

Representative HINSHAW. And you are going to lose more before you get through.

Mr. KAY. We recognize that, sir. We want to accomplish a number of objectives at the same time and that is the difficulty. There are a number of programs, and the people that we do get in we hope to use the very best way we can. We are not getting enough. One reason we are not getting enough is because the draft calls are low.

In the future, should the calls go up, we have the new 6 months' critical skill program, which would be a balance to prevent us from getting any more than we can really use at their highest skill. I think that is the essence of it.

Representative HINSHAW. Why should the Military Establishment expect at all to get as an enlisted man a master of science or a doctor of philosophy?

Mr. BURGESS. The only way——

Representaive HINSHAW. You actually should not expect to get them?

Mr. BURGESS. The only way in the past was through the draft. We will find other ways to get them through officer courses.

Representative HINSHAW. That is right.

Mr. BURGESS. And opening up opportunities for those that are with us, and through this advisory committee that we are forming this month we hope to get at such things as this eyesight matter that you speak of. We hope to get at such things as the constructive service matter that the House and Senate yesterday enacted for doctors, in anticipation of the doctors' draft next year.

We have a lot of work still to do. I do not think we should overlook the work achieved last year and this year.

Representative HINSHAW. Let me say once more there is no excuse whatever, in my opinion, for having a difference in the physical requirements for induction and for officer candidates, for ROTC or otherwise.

Now there is a group in between who can have just as much brains as anybody, who are hurt by the fact that they cannot qualify physically. They are hurt. They certainly are going to take the easiest way out and the quickest way out. You will see.

Now it has been proposed here before our committee, I think, Mr. Chairman, that a scientific corps be set up in the service, in the research service, if you like.

I can remember when Dr. Von Karman had a brevet major-generalship. He wore a major general's stars, and went to Europe and with the advance of Patton's Army in Germany and took over the laboratories of the universities to find out the status, I believe, of the progress in aviation. Dr. Von Karman as everybody knew at the time, could hardly see nor hear nor walk. He was a cripple old man, and is now in rather bad shape, I understand. But there were brains, there was brilliance, that was not limited by his physical condition. His physical condition was bad, and is bad, but he has perfectly marvelous brains.

If we are going to measure capacity by physical standards, we are going to make an awful mistake.

Mr. BURGESS. Mr. Congressman, on the eyesight matter, it is not a standard situation between the services now. There are some variations in this situation.

For example, in this current Air Force ROTC class, they have made some exceptions in eyesight provisions, distinguishing between the rated and nonrated officers, and for persons in the technical professions that are so essential. I quite agree with you, this is one of the problems I tried to point out to Chairman Price, that our programs have been designed toward the development of leadership. There is a long-term rule and long and good reasoning that has gone into the situation that has developed over the years.

We have to modify things as we come into the new technical era, and have new technical problems and new personnel problems presented to us.

Representative HINSHAW. The physical standards are those of Indian fighters.

Mr. BURGESS. Not altogether. As I tried to mention, there are some variations here, and I think some latitude is offered, very wisely.

I am sure that is one of the major problems that will be facing the advisory group we are establishing to iron out situations that we have.

I do think the committee should take note of what was enacted last year, and what we are offering now in the way of better programs and better policies and better opportunities. That all stems from the law you passed here last year.

Chairman Price, I do not want to use my name in regard to this, but I think what we have been able to do at the Department of Defense stemmed from the laws that you gave us, and modifictions that you made in the proposals placed before you.

If it is of any interest to the committee, we have a letter here that was not sent to us in relation to this particular hearing, but came to the Department of Defense some time ago from the Engineering and Scientific Manpower Commissions that pretty well indicates that has been made. If it is of any use to your committee, I will be glad to offer it for the record.

Representative PRICE. I see it is a short letter, Mr. Secretary. Would you mind reading it?

Mr. BURGESS. It is from the Engineering and Scientific Manpower Commissions, dated February 1, 1956, and addressed to the Honorable Charles E. Wilson, Department of Defense, Washington 25, D. C.

It reads as follows:

DEAR SECRETARY WILSON: The Engineering and Scientific Manpower Commissions are gratified that essential and irreplaceable specialized personnel can now, under Public Law 305 and the two executive orders signed by the President on January 6, be utilized far more effectively than ever before for the Nation's defense and general welfare. No small share of the credit for the formulation of the law and the presidential directives must go to Carter L. Burgess, and it is our feeling that the part he played in this important advance deserves much more recognition than we, as engineers and scientists, can give him.

It is the desire of our two commissions to assist the Department of Defense in making the law and the directives work, and to this end we offer you and Mr. Burgess our coperation. It is the least we can do in return for all that Mr. Burgess has done to enable science and technology to make their maximum contribution to the Nation's security.

Very cordially yours,

A. W. DAVISON,
Chairman, Engineering Manpower Commission of Engineers Joint Council.
HOWARD A. MEYERHOFF,
Executive Director, Scientific Manpower Commission.

Representative PRICE. Mr. Secretary, I am familiar with the work you have been doing in this field, and I want to commend you.

Mr. BURGESS. We are far from perfect, Mr. Chairman, and that letter came to us and I was quite glad to get it. I regret it uses my name, but we are very conscious of the matter that you and Congressman Hinshaw have brought to us. We are trying to make modifications, improvements, and sensible arrangements just as soon as we can.

I think one of the things will be the type of legislation that we will bring before you next year, and legislation in itself is not the only thing, Congressman Hinshaw. We have some administrative practices and policies to change.

Representative PRICE. I want to commend my colleague, Congressman Hinshaw. I know of the tremendous amount of work and effort he put in to this over the years.

And I think through your energy and your efforts, Mr. Secretary, many of the things that he has been fighting for have already been attained.

Mr. BURGESS. I hope so. We still make mistakes, but we keep our awareness of further improvement in mind. I think pay is essential. I think the constructive service aspect is essential, Congressman. I think eyesight and other minor health defects keep us from getting the right people to do the right job, and is something we have to look into very thoroughly.

Representative HINSHAW. May I add something about the Navy and Air Force technicians?

Everything that flies that airplane or floats that battleship is controlled by electronic gadgets, and electronic specialists are the ones that I am sure are leaving the fastest because there are plenty of jobs for them to do in maintenance of TV sets at high rates of pay on the outside.

Mr. BURGESS. Yes, sir.

Representative HINSHAW. They can get into a job or go into business for themselves or whatever they want. I think that that has to be recognized as a current thing. I do not think we can stop it by increasing the pay a little bit or increasing some allowances, because more money can be made on the outside than the Congress can afford to pay. You do not want to continually train new technicians.

Mr. BURGESS. It is a very wasteful practice.

Representative HINSHAW. It is a very wasteful practice. There was a practice set up during the last war finally, after considerable effort, in which I happened to have a part, and which involved people in my congressional district. It was known as the Lockheed Service Corp. Large numbers of technicians were sent to Europe under the Lockheed Service Corp. plan, into England and there they did maintenance work. They are perfectly competent people. They have been trained at it for years.

Now, the civilian maintenance of these gadgets, except at sea or at remote locations, is easily enough obtained by contract with such an organization. The same thing is true with aircraft.

For years we have had maintenance firms around the country who have been crazy to get business. They can maintain at a fraction of the cost that you can do it in either the Air Force or the Navy, on land. At sea this is a different thing, of course, and at remote locations. But it is a cheaper thing to do and a better thing to do, on the whole, to entrust to those who are experienced—maybe they achieved their first experience in the Navy or the Air Force—generally so.

Mr. BURGESS. That is what makes them pretty good.

Representative HINSHAW. Exactly. But they are now working for Pacific Air Motive or Lockheed Air Service or American Airlines, or somebody else like that, and they are perfectly competent and these people will be delighted to contract for the work.

Mr. BURGESS. That is not overlooked, Mr. Congressman, because, in my travels around the country I hear many stories about these very young men that we have given the basic training to, who left to take the lucrative jobs in business, and are doing the contract work on the bases and are seeing their old associates and colleagues.

Mr. BURGESS. At much higher pay.

Representative HINSHAW. $2.60 an hour versus $75 a month.

Mr. BURGESS. If I might I would like to suggest a thought to the committee and the chairman here as regards witnesses that come before you from industry. I think one of the things that industry can do is to take on some of this skilled technician training that we are giving, in their own interest and the national interest.

I heard a figure—and I never heard it questioned—that of all the electronic specialists in this country, we originally trained about one-third of those specialists.

Representative HINSHAW. I believe so.

Mr. BURGESS. And I do not consider it a complete loss, I hear people——

Representative PRICE. The percentage will be greater.

Mr. BURGESS. Yes, sir.

I hear people talk about the great loss to the armed services. I do not consider it a complete loss by any means, because we are building up the skill——

Representative HINSHAW. The skill level of the country, as a matter of fact.

Mr. BURGESS. The country is enjoying these efforts. We are running a big training establishment. The more of the training establishment we run the less in our actual combat effectiveness. Too much

of our effort is immobilized in the training field. We have to hold on to these men after training so that they can get out into the practical field. We cannot keep so many of our specialists in training, as against the number actually giving useful service. We have to build our business just like industry is built. When we have industry doing more of its own training, the demand is reduced on the military, and then we can enjoy some benefits from our training. However, it is not a total loss. I do not think that it should be characterized as a total loss.

Representative HINSHAW. It is not a total loss.

Representative PRICE. Thank you, Mr. Secretary. We appreciate your cooperation.

Mr. BURGESS. Thank you very much, sir.

Representative PRICE. The next witness is Mr. Dael Wolfle, American Association for the Advancement of Science.

STATEMENT OF DAEL WOLFLE, EXECUTIVE OFFICER, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Mr. WOLFLE. Mr. Chairman, Mr. Hinshaw, I have a statement here that will require about 15 minutes. In view of the time, I would be happy to put it in the record, and let you ask what questions you have, and let you read it.

Representative PRICE. I think that would be advisable, Mr. Wolfle. The statement may be inserted in the record at this point.

(The statement referred to follows:)

STATEMENT OF DAEL WOLFLE

My name is Dael Wolfle. I am the executive officer of the American Association for the Advancement of Science. That 108-year-old organization of American scientists is very keenly interested in the problems to which you are devoting these hearings. From 1950 to 1954 I served as director of the Commission on Human Resources and Advanced Training, a commission that was financed by the Rockefeller Foundation and that was established by the National Academy of Sciences and several other scholarly bodies to study the supply of scientists and other specialists in the United States, the demands for the services of scientists and other specialists, and the extent to which we are making good use of the Nation's intellectual resources. The Commission was among the pioneers in conducting detailed investigations of the problems that concern us today. Its findings and recommendations were published in 1954 in a report entitled "America's Resources of Specialized Talent."

The nature and magnitude of the Nation's manpower problem, and the comparisons between the United States and Soviet Russia have been so well described in a number of published sources, including the Committee Print entitled "Engineering and Scientific Manpower in the United States, Western Europe, and Soviet Russia," that I will not take time to repeat that information, but will turn directly to the problem of what we can do about the situation.

There is an immediate problem and there is also a long-range one. The immediate problem is to secure as good use as we can of the Nation's present resources of scientists and engineers. We cannot produce more overnight; we must do with what we have. The problem is therefore one of effective utilization rather than one of improved education. I would like to suggest four points concerning the present situation.

1. Greater public understanding of the situation is necessary. Recent comparisons between the United States and Soviet Russia have helped to bring the problem into widespread public discussion. Such hearings as these and the work of the President's National Committee for the Development of Scientists and Engineers can be of major importance in bringing about even wider understanding of the problem, its causes, and the necessity of taking the following steps.

2. Industry can make better use of the present supply of scientists and engineers. Industry has stepped up its research efforts and improved its utilization of engineers since 1950, but further improvement is still possible.

3. The policies and practices of the military services can be altered to contribute to better utilization. Military policy has improved in this respect, but further improvement is possible and desirable. Incidentally, there are two aspects to this problem. One is the question of how the knowledge and skill of a young scientist is employed during his period of military service. The other is the impact of the policies and changes of policies concerning induction, Reserve obligations, and ROTC obligations on the young scientist or engineer who has not yet entered military service. In addition to the reports of maldutilization of scientists in uniform, there is a great deal of wasted time, disruption of plans, and postponement or abandonment of higher education that result from uncertainty over the questions of when and how a young man will be expected to fulfill a military obligation.

4. The fourth aspect of the immediate situation is the desirability of placing greater emphasis upon basic research. Our qualitative shortage is more severe than our quantitative one. We lack original ideas more acutely than we lack men to carry out the more routine aspects of scientific and engineering work.

For the immediate future, we can use such steps as the ones indicated to ease our technical manpower problems. If the emergency gets greater, if conditions make necessary, we can take the further step of establishing priorities for using our present supply of scientists and engineers. We are still a great technical Nation and we have a large number of scientists and engineers. If conditions warrant, we can suspend some of the less vital to concentrate on the more vital activities for which they are trained and qualified.

When we turn to the long-term problem, the first question to ask is how we got into the present situation. Probably the most fundamental fact involved is that our economic growth and our military strength have come very rapidly to depend so much more directly on scientific and technological progress than was true 20 years ago that the educational system of the country has not been able to keep up with the changed situation. In an age of nuclear weapons, jet propulsion, radar, plastics, and electronic brains we are preparing students for college in elementary and secondary schools that have changed but little in their basic policies during the few years that were required to bring those developments from the research laboratory to the positions they occupy today. To complicate matters, the young men and women who are entering college are the members of the thin generation born during the depression 30's.

The present situation can be described in terms of several interrelated trends. First, the increasingly technological character and the increasing size and complexity of our national economy create growing demands for scientists, engineers, and other highly trained specialists. We can confidently expect this trend to continue.

Second, scientific, engineering, and related industrial changes are coming at a more and more rapid pace. Witness the mushrooming developments in electronics of the past decade or so and the speed with which we moved from the first atomic bomb to the present diversity of thermonuclear weapons and peaceful uses of atomic energy. The coming impact of automation will unquestionably provide another illustration of our dependence upon a substantial corps of scientists and engineers who are so well and flexibly educated that they can move into new areas and handle new problems.

Third, during the past half century the secondary schools of the country have become a part of a nearly universal educational system. Fifty years ago few students finished high-school but most of those who did went on to college. It was then appropriate for high schools to devote a good deal of emphasis to college preparatory work. During the past half century the number of pupils attending high school has increased very greatly, but a smaller and smaller percentage went on to college. In this situation, school officials very naturally gave most of their attention to the courses, the methods of instruction, and the expected levels of performance appropriate to students who did not intend to enter college. There have been both good and bad aspects of this policy. One of the bad effects has been a decreased emphasis on science and mathematics and a decreased insistence upon the kind of intellectual rigor that provides best preparation for high-level college work.

Fourth, the percentage of high-school graduates who enter college is now rapidly increasing, and again we must expect, as we did half a century ago, to have half or more of high-school graduates enter college.

These four trends lead me to believe that a major change is necessary in our educational philosophy. We must pay greater attention to the education of the ablest students; we must insist upon more rigorous education of the students who have the ability to do rigorous work; we must make thinking respectable; we must identify and motivate the brightest youngsters and help them to acquire the education that will enable the country to make full use of their abilities. In too many cases the brightest boys and girls have been the neglected children of the school system. We need not lessen the effort to educate average and handicapped youngsters, but we must certainly improve the education we give to the ablest ones.

There are several things we can do to bring about this change and thereby to make more effective use of our intellectual resources. I would like to describe half a dozen that seem particularly important.

1. School policies in this country are determined in thousands of local communities. It is therefore necessary for the public to understand the necessity of better education and the Nation's need for well-trained scientists, engineers, and other specialists. Industry, citizen's groups, White House conferences, associations such as the one I represent, congressional actions and hearings can all contribute to this end. The job is too big for any one of these groups to handle alone, but it is too important for any of us to neglect. Only as we get full public support can we bring about the more specific changes that are necessary.

2. Teaching must be improved, particularly in science and mathematics for it is in those areas that the need is most acute, and there is where teaching is suffering most severely. The competition of industry and Government for young college graduates who might become teachers of science and mathematics is so great as to rob the schools of many of the potentially best teachers. To meet this situation, the suggestion has been made that industry declare a moratorium on the hiring of science teachers. This suggestion seems to me to be unrealistic and positively detrimental. It would make teaching an even less attractive career than it is now. The better course would be to increase the attractiveness of a teaching career so that more able young men and women would want to become teachers. Salaries are obviously not the only factor involved in the comparative attractiveness of the teaching profession, but they are obviously a very important one. In terms of what he can buy with his money the teacher has dropped from the upper third of all income groups 20 years ago to the bottom third now. In real money, the average salary of big city high-school teachers is no greater than it was 50 years ago, while the real wages of most other groups have increased substantially. Beardsley Ruml has computed that a salary increase of 70 percent would be necessary to restore big city high-school teachers to the relative economic position they occupied 50 years ago. To restore the principals of those schools to their economic position of 50 years ago would require an average increase of 160 percent.

There would be very great difficulties in making a major across-the-board increase in the salaries of all teachers. There would be great difficultes, and also serious inequites, in increasing the salaries of scence and mathematics teachers over those of their colleagues in other fields. But what we can do is to bring about greater differentials among teachers' salaries and to make those differentials dependent upon merit. Teaching will become a much more attractive career for a bright young man or woman if he can look forward to rewards for merit and the opportunity to earn a salary that will let him live in moderate comfort and send his children to college.

In this respect perhaps we should take a leaf from the Russian book. Much attention has been given to the numbers of scientists being trained in Russia. Less attention has been given to the methods used to secure that result. It is an ironical fact that Russia has been using with a vengeance the supposedly capitalistic techniques of giving teachers and scientists high salaries, special privileges, and much honor. It is not surprising that bright Russian students want to become scientists.

3. Scientists and scientific organizations can help to improve high school teaching and high school education. By and large, it must be admitted, scientists have held aloof from secondary school problems. They are rapidly changing that attitude. By and large, it must be admitted, there has been a considerable gulf between scientists and the professional educators who are responsible for training teachers and administering schools. That attitude is also changing. My own association, the American Association for the Advancement of Science, is very actively engaged in an effort to improve scientific education, and the place on which we are concentrating our efforts is the high school. Because we repre-

sent all branches of science and because our members come from Government and industry as well as from colleges and universities, we can help to bring about the cooperation between scientists and high school teachers and administrators that is necessary for the improved education we consider essential.

4. The schools themselves can make some changes. In too many cases school districts are so small as to be grossly inefficient. There are not enough pupils and there is not enough money to permit hiring the teachers and giving the courses that are necessary to provide a good education for the brightest pupils. Moreover, schools can insist upon better qualifications in the teachers they hire. Far too many courses in science and mathematics are taught by teachers who know little of those subjects and who never expected to teach them.

5. There is a money problem. In addition to the money required for better schools there is the money required to send able high school graduates to college. I do not think that lack of money is the principal reason for the loss of bright students from the school system; lack of motivation is probably a more important factor. Scholarships alone will not solve our present difficulties. But scholarships can help, for it is certainly true that each year a considerable number of bright students graduate from high school but are unable to afford college. Many now get scholarships. Many do not. An additional large-scale scholarship program would probably work most effectively if the winning of a scholarship was based solely on merit, but the amount of the scholarship was determined by the size of the family's resources, and if the scholarship was not tied to any particular field of interest or study.

There is a second value of a large scholarship program, the generally stimulating influence it can have on many students other than the scholarship winners. The National Merit Scholarship program, established last year by the Ford Foundation, pays the expenses of some students who could not otherwise go to college. It has the additional effect of stimulating a great many more students to compete for the scholarships, to think more seriously about their own educational plans, and to seek other means of support even if they fail to win a National Merit Scholarship.

In considering the merits of Federal scholarship recommendations, this important secondary effect should be considered along with the more direct effect of the number of students whose expenses would be wholly or partially paid by scholarship money.

6. The final point I wish to make is the desirability of a more consistent national policy concerning problems of education, science, and manpower. Here again we can compare the United States with Russia. Whether we like the situation or not, we must agree that for several decades Russia has been following a consistent policy of emphasizing science and mathematics throughout the school system, of pushing the ablest students on to higher levels, of rewarding its scientists and professors highly, of making it an honor to get into higher educational levels, of not allowing military requirements to interfere with the flow of university graduates or the beginning of their careers, and, as a result, of producing a rapidly increasing number of graduates in science and engineering. We need not get into a numbers race with Russia; in fact, I do not think we should. We need not use all of the methods that Russia has used. In fact there would be strong opposition to the extreme narrowness of the Russian curriculum. But we can analyze our own situation and needs, decide what is desirable for the United States, and formulate a set of guiding principles that will provide a firm basis for action. As far as I can see, we do not now have such a policy. On the contrary, we are sometimes quite inconsistent. We deplore the quality of teaching in our high schools, but we do not pay the good teachers high enough salaries to keep them in the schools. We clamor for more scientists, but we use individual scientists for fatigue and K. P. duty. We give more honor to the clever inventor than to the man who made the basic discovery that the inventor exploits. Sometimes we discriminate in petty ways against the scientists; when a man with a Ph. D. in physics or chemistry or biology is commissioned in the military services or the Public Health Service he is given a lower salary and lower seniority rank than are accorded a physician, a dentist, or a veterinarian.

To bring about a wise and consistent policy will require a good deal of effort, but the effort is necessary. I hope that the work of this committee will contribute to that end.

Representative PRICE. In the meantime, could you make a brief statement that might summarize this statement?

Mr. WOLFLE. I will be glad to.

I suggest that the problem has been so frequently described, that I am not going to repeat it, but just express a few opinions about what we ought to do.

Representative PRICE. First may I ask this: You do agree with most of the testimony that we have had here, so far, that there is a problem?

Mr. WOLFLE. I agree.

Representative PRICE. That there is a problem as to the shortage of scientific and engineering people?

Mr. WOLFLE. Yes.

Representative PRICE. You may proceed.

Mr. WOLFLE. With respect to immediate problems, we need better utilization, and that has been explored somewhat in previous testimony, particularly with respect to military use.

I would like to turn to the longer-time problem. The basic reason, it seems to me, for the present shortage situation is the fact that our economic growth and our military requirements have come to depend so intimately on science and engineering that the schools simply have not had time to catch up with the situation. We are putting people through grade schools and high schools the basic policies of which have not changed essentially in the past 20 years.

We have an increasing demand for scientists and engineers, and we can expect that trend to continue. The requirements are for greater flexibility because of rapid job changes. But the school systems which are preparing future scientists were designed primarily to meet the very large influx during the past half century of people who were not planning to go to college.

We can forgive the schools, and we can understand the situation, but one of the unfortunate aspects is a loss of rigor, a deemphasis on science, mathematics, and a preliminary education for students who have an interest in science and mathematics.

Representative PRICE. Would you care to give your opinion why this is?

Mr. WOLFLE. When we go back 50 years or so, the high school was primarily an institution for the training of people preparing to go to college. At that time there was a good deal of emphasis on college preparatory work. A relatively small number of people went to high school. During the 1920's and 1930's the number of people going to high school grew very large until it was practically universal. But the percentage of those high-school students who were planning to go to college gradually dropped through the decades, and we had a problem of mass education, to which the schools responded by lowering standards, by introducing a great variety of other courses, by changing the character of the school from a college preparatory institution to one that emphasized vocational citizenship, and social training, and that only to a smaller extent in a preparatory institution. This has to be changed. I think that is our basic educational problem.

Representative PRICE. I note in your statement you say:

> Industry can make better use of the present supply of scientists and engineers. Industry has stepped up its research efforts and improved its utilization of engineers since 1950, but further improvement is still possible.

Do you care to elaborate on that statement?

Mr. WOLFLE. My information here is from people in industry and in engineering fields. They report that industry has done a good deal in the way of going through its own staff members, spotting the people who have through one channel or another drifted away from the duties they can perform most effectively and bringing them back into technical work. But they do not feel that the job is completely done.

Representative PRICE. Now, what is your suggestion to remedy this situation, briefly? I notice you have in your statement——

Mr. WOLFLE. Are you referring particularly to this point or in general?

Representative PRICE. I would like to refer to the overall problem of solving the shortage. Do you have any recommendation for immediate action or a recommendation for a long-range action?

Mr. WOLFLE. I would make recommendations for long-range action. Beginning on page 6, I have listed a half dozen or so.

Representative PRICE. On page 7 you have a statement that "Perhaps we should take a leaf from the Russian book." Would you care to elaborate on that statement?

Mr. WOLFLE. The Russian educational system has placed a great deal of emphasis on science and mathematics throughout the elementary and secondary and higher levels. What I had reference to here is the fact that Russia is producing scientists and engineers not wholly by dictatorial means, but by making careers in science and engineering and in teaching into attractive careers. They are using techniques that we are inclined to think are capitalistic. Their scientists receive honors, have high salaries, prestige, and so on.

Representative PRICE. On page 8 you say:

> The American Association for the Advancement of Science is very actively engaged in an effort to improve scientific education, and the place on which we are concentrating our efforts is the high school.

What sort of effort are you making in that regard? What are you doing?

Mr. WOLFLE. The scientists of the country on the whole have remained quite aloof from teaching and teaching problems, and there has been a considerable gulf between the scientists of the country and the professional educators who are responsible for teacher training and for school administration.

Sometimes there has been overt criticism back and forth between these groups.

The scientists have to accept some responsibility for the deficiencies in teaching at the secondary-school level.

I think the more thoughtful observers in the field are aware of that. We are an organization of scientists. One of the things we are doing, therefore, is to try to bring scientists, on the one hand, and the school people on the other, together, in working out programs to train teachers and to improve curriculums. This we do through a great variety of means, through some writing, getting people together in conferences, through some experimental studies. It is largely a problem of education of getting the scientists and school administrators to work together. This we do.

Representative PRICE. How can you do the things that you do? What can be done to stimulate more attention to scientific training in the secondary schools? What kind of action can be taken? Is there anything that Government can do that you can think of?

Representative HINSHAW. I have a suggestion, Mr. Chairman.

Representative PRICE. Mr. Hinshaw.

Representative HINSHAW. That scientists in greater numbers run for positions on school boards, and thereby place themselves in a position to be direct guides of the educational system, instead of merely talking about it.

Mr. WOLFLE. There are—maybe I am confused, because I thought Mr. Price had intended to ask what the Federal Government——

Representative PRICE. Not necessarily.

Representative HINSHAW. He said scientists.

Representative PRICE. Scientists.

Mr. WOLFLE. All right.

Representative PRICE. What positive recommendation would your organization make to correct the existing situation as regards the scientific work in the secondary schools?

Mr. WOLFLE. As to what scientific organizations can do? The sort of thing Mr. Hinshaw suggested, of active participation. That, of course, is at a local community level. And the scientific organization that is working best at the level is the American Chemical Society.

The American Chemical Society has local sections scattered all over the country. The members of those sections are interesting themselves in school problems, for one simple thing—just getting acquainted with high-school teachers and encouraging them.

There are summer positions in scientific industries for high-school science teachers. We are this year—and again next year—trying a motivating device on a sampling basis. We made up kits of books—some are biographies of scientists, some are high-school level or semi-popular books about science—and are sending them around on a rotating basis. We have in each of these kits 25 books. New kits are sent at about a 2 months' interval to 66 small high schools in the United States. In some schools, reports indicate, the books are not being read very much. In other schools our records show that all of the books are in use the day after a kit arrives. These traveling libraries are one device.

The salary problem we must come back to in any consideration of how to improve science teaching, for the good teachers cannot see much prospect of advancement, and for that reason many leave teaching.

Representative HINSHAW. I hope you will pardon me for interjecting that thought, but both the engineer and the scientist are prone to sit back. He may be critical of the situation, and his criticisms may be constructive, but, in order to have a direct part in the school management and curriculums and all the rest of it, if he would become a candidate for the school board, and run for election and learn what it takes to get to be a school-board member, he would be doing very well indeed.

Mr. WOLFLE. He would. And this is one of the problems.

By and large they have not only remained aloof from the school boards, but they have remained aloof from the whole range of problems.

Representative HINSHAW. They are not inhuman, you know, the scientists.

Mr. WOLFLE. No.

Representative HINSHAW. Or unhuman, rather.

Mr. WOLFLE. But this has been an area in which they have simply not been interested until relatively recently.

Representative HINSHAW. They should take their part in the organization work of our social system as well as in their laboratory, I think.

Representative DURHAM. Mr. Wolfle.

Representative PRICE. Mr. Durham.

Representative DURHAM. This may have been covered. I notice in the doctor's statement here, that you say that one of the difficulties is qualitative instead of quantitative. Is that from lack of assignment? What is the difficulty?

Mr. WOLFLE. The people attempting to hire young scientists and engineers put greater emphasis on their difficulties in getting really well-qualified ones than on the difficulty of getting numbers. That is one point that I had in mind. It is easy to count up the numbers of people graduating but it is harder to make an appraisal of the quality. There is general agreement, I believe, among the people who have been most involved in consideration of scientific and engineering manpower problems, that we must give more thought to the quality question than the pure number question in the consideration of the future educational programs, and this, I think, becomes particularly clear when we consider the future. We talk now of a shortage, but the schools are going to be flooded, as the baby boom of the war and postwar years get through high school and into college. The same kind of crowding of high schools that led to some of the weakening of rigorous intellectual discipline and weakening of science and mathematics and English subjects in the high schools is likely to endanger colleges in much the same way. We have to worry about a qualitative weakening in college education.

Representative DURHAM. You used the word "qualitative." We have so many in my section in the university at Chapel Hill that get up to a master's degree and a commission position, and marry and have a very promising future and cannot go on and secure their doctorate degree.

Does that have any effect on the qualitative end result? I have noticed it frequently. They will get married with a master's degree, when they could go on, and they have the ability and know how to continue and become a man of quality instead of quantitative. In other words, we are dropping so many off at that level.

Mr. WOLFLE. I do not know.

Representative DURHAM. I thought maybe your organization would know, probably have given some thought to that. That is, whether it is an economic thing in producing the quality.

Mr. WOLFLE. There is an ecomonic problem in educating all of high quality. Good brains are not highly associated with family wealth, so that there are bright youngsters at all economic levels. The ones who are from poorer homes are less likely to have opportunities to go to college and are less likely to develop an interest in doing so.

Representative DURHAM. Do you think the uncertainty at the present time, taking the lower level, after he graduates from high school and is going into science at the college level, the uncertainty from the military standpoint, is having much of an effect on the numbers.

Mr. WOLFLE. I suspect that it is. I know of only one statistical study and that was made among college students. The results indicated that the boys were taking things more or less in stride, with an expectation that sooner or later they were going to have to give a period of military service. However, discussion with individual young men leads me to suspect that there is a great deal of indefiniteness, loss of time, uncertainty, and sometimes the postponement or abandonment of educational plans.

Representative PRICE. Are there any further questions? If not, thank you very much. The committee appreciates your cooperation and your fine statement.

Representative HINSHAW. According to his statement, I think he has made a thorough study.

Mr. WOLFLE. Thank you.

Representative PRICE. The next witness is Dr. Rabi, of Columbia University.

Dr. Rabi, you know the purpose of the committee session. I wonder if you would agree with some of the other witnesses that we do have a shortage of manpower in this field.

STATEMENT OF DR. I. I. RABI, COLUMBIA UNIVERSITY

Dr. RABI. I do agree, Mr. Price, that there is such a shortage. I regret very much, due to the pressure of other things, I was unable to answer your letter the way I would like to have answered it.

I have no prepared statement, but just a few suggestions relative to some of the topics which were suggested for consideration. I cannot say I have had good experience in this field either, because I have had very little to do in the last 30 years in teaching on the college level and I have had very brief teaching in the high school level. Most of my teaching has been done on the graduate and research level.

I would like to make a few remarks to the item you have under IV; why are not students enrolling in science and engineering courses?

From my observation and just talking to people, I have the feeling that one of the important reasons is inadequate preparation in the fundamental subjects which would enable them to enter into science and engineering courses at college, therefore they would have to postpone their preparation and go into other fields particularly in science, the rewards are not so terribly different, and the scientific work on the whole is not easy.

This brings me to the point I really wish to make under V, recommended Federal action to alleviate the problem to encourage an adequate supply of professionally trained scientific and engineering manpower.

To my mind it would be difficult—you certainly know better—to have direct Federal intervention pushing people toward one field or another. I think it would encounter a lot of resistance and properly so.

It seems to me that mathematics, traditionally, and historically, has been a fundamental element of education in the humanities and in the sciences.

I understand that about half of the judges on the British bench have been trained in mathematics. So that if the Federal Government, through some system, which I would like to suggest, of scholarships,

were to encourage the study of mathematics in the high schools, in the first place that would contribute to broad fundamental education of any educated man and it is useful in teaching people to think.

On the other hand, it is indispensable for a scientific or engineering career.

In discussing some of these matters with Sir George Thompson, the British physicist at Cambridge, he tells me that there are 80,000 students enrolled in the colleges and universities in England, and of those about 60,000 receive Government support.

I would like to suggest that you set up a system of Federal scholarships to the amount of something like $500 to any high school graduate who has completed successfully and has passed an examination not at a prohibitive level but more or less equivalent to the college entrance examination in the traditional fundamental subjects of mathematics in the high school. That is, elementary algebra, plane geometry, intermediate algebra, trigonometry, solid geometry. Anybody who has passed this examination would get one of these scholarships.

Representative DURHAM. Would you be thinking of doing that after the graduate level of high schools?

Dr. RABI. High school seniors would take this examination just the way they take the college entrance examination. This is my suggestion, at least. This would put a certain premium on that, and I think, indirectly, would very greatly improve the teaching and also would interest students and make a demand for these subjects. It would not preclude anybody.

After that, a man could study history or anything else.

Representative DURHAM. Do you think it would stimulate the ones in the 10th grade and 9th grade and all down the line?

Dr. RABI. That is right.

Representative PRICE. They would not be required to take scientific subjects?

Dr. RABI. No. There is no compulsion in anything I suggest because I do not like the idea of compulsion or direction of people.

I would add one other point: That if at the end of his freshman year in college, of those who do go to college, he has taken and completed a course in calculus, I would give him another $500 scholarship for the ensuing year. Calculus again has been a traditional subject.

At Yale, 75 years ago, there was a formal burning of calculus books, but still everybody had to take it.

My suggestion goes along the direction of giving the student a free choice which he does not have when he enters college otherwise.

Representative DURHAM. He would have to have pretty good high school training to take calculus in his freshman year in college.

Dr. RABI. They do in New York. If there is interest in it they can. People who would teach these subjects are not so scarce. People who can teach solid and the plane geometry and so forth, in other words.

I think we could achieve that and get back to the sort of level of training in which more people would have the choice of entering these fields. I think through the operation of economic laws these measures should take care of the people further on. It may be that, after looking at this, one would require more extensive Federal support and incentives.

I urge this as a practical suggestion and on which one could make a beginning without getting the Federal Government into any sort of dictation or pushing people in one direction or another. We are merely saying that here is a fundamental subject which is good for everything and one that an educated man needs, but, in addition, is indispensable for a scientific or engineering career.

Representative PRICE. Would you put physics or chemistry in this classification?

Dr. RABI. That is right; merely on the passage of an examination such as you have for entering college.

Representative PRICE. Would you put physics or chemistry in there?

Dr. RABI. No. In other words, I am talking something that is essential, fundamental, and neutral. I would not like to have the scientists accused of trying to push the people into science.

Representative PRICE. You would eliminate discrimination. The program would be open to everyone who seeks an education?

Dr. RABI. Yes, sir. This would be a scholarship which he would use. This is not an award for a promise to perform.

Representative PRICE. It would not discriminate as against the scientifically inclined and the liberal arts inclined?

Dr. RABI. That is right. There is no discrimination or pressure involved whatever. But it opens the door to people going into science. It does not close any other door.

These are the only points I had to make.

Representative HINSHAW. Dr. Rabi, in this connection, would you have a limited number of these $500 grants to be made, or would you have the grant made to anyone who passed the examination at a certain level?

Dr. RABI. I would like to see this given to anyone who took the examination and passed, period, without saying that he passes at 70 or 80 or something else.

Representative PRICE. Not a competitive examination?

Dr. RABI. That is right. A man has to pass. This is not some idea of special award or special gifts. If a man can master this subject sufficiently to pass a reasonably good examination—this sort of level you would have in the college entrance examination and given nationally—you would pay him $500.

Representative PRICE. That would about pay his tuition for 1 year of college.

Dr. RABI. Yes. It would do even more than that from the standpoint of parents who are paying taxes. This would be a great incentive both at home and for the boy himself. It makes him independent. I would not put any means qualifications. Even if a boy comes from a well-to-do family, he might want to travel on his own.

Representative DURHAM. I think a great deal of your suggestion, but the difficulty we would face here is to have the other sciences coming in and asking us to do it for them, if we could.

Dr. RABI. Yes.

Representative DURHAM. In Congress, you know, we have other groups which would immediately move in on us for their education.

Representative PRICE. This eliminates that conflict. This makes it open to everybody.

Representative HINSHAW. It would make it open to everybody.

Representative DURHAM. That is perhaps true, but you would ha to have almost some guide of the subjects, would you not, that wou be required?

Dr. RABI. Yes. This subject, which is nothing but the tradition subject. This subject is something which when I was a boy that eve high school boy who wanted to go to college and enter without cond tions would take.

Representative DURHAM. It would eliminate some clamor, if y put it at the high school level.

Dr. RABI. It would have the effect of tightening up the curriculu

Representative DURHAM. He would not have made up his mind the high-school level as to what he was going to do. But he wou have to do that under your suggestion.

Dr. RABI. This would not fix him in any direction.

Representative PRICE. That is not the purpose of your thinkin He does not have to make up his mind, but he takes mathemati which is basic for an engineering and scientific career later on. Y prepare him for that, but he does not have to follow that course.

Representative HINSHAW. You prepare him for any career if takes mathematics.

Dr. RABI. It is certainly good for law.

Representative HINSHAW. It is good preparation for law or an thing else.

Representative PRICE. You would stimulate an interest in all yo school systems to have strong mathematics divisions and they wou form their curricula with that in mind, to prepare the students f passing the examinations.

Dr. RABI. Yes. They can boast about what fraction of studen who get by and it would be a matter of pride.

Representative PRICE. I understand that the percent of secondar school students who participate in mathematics is about 25 percen You might raise that to 75 percent.

Dr. RABI. Yes, sir. That was my first point.

These others do not have the full opportunity if the schools do n offer the right preparation. This scheme would give a real incentiv The parent-teacher organizations would get after it.

Representative HINSHAW. It would be given, I take it, to an student who is graduating from a secondary school of any kind.

Dr. RABI. Yes, sir.

Representative HINSHAW. Regardless of whether it is a publi school or private school or religious school or anything else.

Dr. RABI. Our objective is something else.

Representative PRICE. Our objective is the individual student.

Dr. RABI. That is right. It is not given to the school.

Representative DURHAM. Your suggestion is to be commended.

Representative HINSHAW. It is to be remarked upon that everyon who has come here to testify on this subject has mentioned the lo degree to which the teaching and the study of mathematics has de scended in our secondary schools. Mathematics, of course, is funda mental to these things, as you point out. But they have gone int teaching tapdancing and all sorts of things in high school, includin social subjects.

I take it that the scientist, as such, does not agree with the progressiv system of education, but would be inclined toward the old syste

which had something to do with drilling it into them and not allowing it to be entirely up to choice.

Dr. RABI. As far as I can see, you can have your choice. You can have an easy youth, and a tough time in college and graduate school, or you can distribute the load. I am suggesting that you distribute the load, and get the tools when the mind is young, fresh, and capable of receiving it.

Representative HINSHAW. I know it can be done because I took courses in both differential and integral calculus and passed them satisfactorily by the time I was 16 years old.

Dr. RABI. And it has not done you any harm.

Representative HINSHAW. It is perfectly possible to do.

Representative DURHAM. How does England apply the funds that they expend? You mentioned the fact that out of the 80,000, 60,000 were subsidized.

Dr. RABI. As I understand it, and I am not an authority, there is a University Grants Committee and they do it through that. The exact mechanism I do not know. I am sure the information is available.

Representative HINSHAW. I wonder where it is available.

Dr. RABI. You could probably get it right from the cultural attaché of the British Embassy.

Representative DURHAM. It would be interesting to have, Mr. Chairman.

Representative PRICE. We will check into that for the benefit of the committee and perhaps insert it in the record.

Representative HINSHAW. I think so, at this point in the record, Mr. Chairman.

Representative PRICE. Without objection, we will do that.

(The information referred to follows:)

UNIVERSITY GRANTS COMMITTEE

The University Grants Committee is a standing committee of the Treasury; it consists of a number of honorary members, appointed by the Chancellor of the Exchequer from members of the academic staffs of the universities and other persons with wide experience of university administration and education, and a small permanent staff. Items of reference since 1946 have been "to inquire into the financial needs of university education in Great Britain; to advise the Government as to the application of any grant made by Parliament toward meeting them; to collect, examine, and make available information relating to university education throughout the United Kingdom; and to assist, in consultation with the universities and other bodies concerned, with the preparation and execution of such plans for the development of the universities as may from time to time be required in order to insure that they are fully adequate to national needs." The committee conceives its function as "not one of direction, but of stimulation, coordination, and advice." The universities remain free to formulate their own academic policy, and to draw up their own study programs, and to appoint their own staff.

Representative PRICE. How about the mechanics of marking the papers? Would it be uniform in every school district in the country?

Representative HINSHAW. The same system can be used as is used presently for the candidates of the Military and Naval Academy. It is very simple. It can be done under the direction of the local postmaster or some other Federal official such as a civil-service examiner.

Representative PRICE. Do you have any further statement?

Dr. RABI. That is about all I had time for to prepare my thinking.

Representative PRICE. Do you have any other suggestion?

Dr. RABI. I agree with what other people have said. I would like to see our high-school graduates more capable of writing an English paragraph.

Representative DURHAM. Doctor, what do you think of the use we are making now of the scientific numbers that we already have in the United States?

Dr. RABI. I am no authority on it, and I really have not studied it. I imagine people do the best they can. You can always point out inefficiencies but these inefficiencies come as a result of an organic process. We have a certain way of doing things which has just grown up.

Representative DURHAM. That is true.

Dr. RABI. I do not see what good I can do by complaining that this or that is done inefficiently.

Representative DURHAM. I was thinking primarily, of course, of the vast sum of money we are expending now for research, principally the two committees that we serve on, the armed services and this committee, which amounts to quite a sizable sum of money, which is more or less directed to a certain extent by a Government agency although it is under private contracts. We do have those who go into the research jobs throughout the country, and more or less, to a certain extent, tell them what they have to do.

Dr. RABI. To that I would only remark, and it is just my own prejudice, that we have carried the principle of competition somewhat too far in some cases, where we have two competing groups, neither of which has enough personnel to do a good job. We would do much better to coalesce and really make a first-grade team than to have two second-rate teams competing with one another. I do not wish to criticize any particular project, but I think this principle of competition has been carried a bit far.

Representative DURHAM. That is primarily what I was thinking of because we do have spirited competition with one branch of the service trying to get ahead with some new idea, a new type of propulsion, weapon, or whatever it might be, that is necessary for the Armed Forces as against another branch of the service.

I think you have a point there that to me is well taken.

Dr. RABI. I was thinking principally of some company getting a contract to do something and they do not have the personnel and they go out in the market and try to get them from some other fellow. When they finish, nobody is real well off as far as the high-grade personnel are concerned, who are capable of leading a very difficult research and development program.

Representative DURHAM. Of course, we found the same difficulty in the early days of the Second World War in the intelligence field where we had scattered it all over the lot and every agency in the Government tried to collect intelligence without any coordination. If we had a complete coordinating agency somewhere, over and above, do you think it would have any effect?

Dr. RABI. I would be afraid of that, sir. I think just a moderation of this principle of competition would bring us a long way. I am afraid of an overall directing agency. If that is bad, then everything is bad.

Representative DURHAM. We find it difficult, even after we passed the Unification Act, of applying it effectively. That is the point I am thinking about. It is applicable to this field because it has grown so large. I do not remember the exact sum we spend each year, but we spend approximately $3 million or more, primarily for the services and the AEC.

Representative PRICE. Thank you very much, Dr. Rabi. We appreciate your kindness in coming down here. We always value your suggestions.

Dr. RABI. Thank you, sir.

Representative PRICE. The next witness will be Dr. Lee DuBridge of the California Institute of Technology.

Representative HINSHAW. It seems to me that we have heard from Dr. DuBridge and I have in particular.

STATEMENT OF DR. LEE DuBRIDGE, CALIFORNIA INSTITUTE OF TECHNOLOGY

Dr. DUBRIDGE. Thank you, sir.

Representative PRICE. Would you care to make a formal statement?

Dr. DUBRIDGE. I have prepared a letter to you, sir, which I can present as a statement. I can either read it or summarize it and put it in the record, as you prefer. It will take me about 10 minutes to go through it.

Representative PRICE. I think you probably can go through it.

Dr. DUBRIDGE. Some of the parts bear on the suggestion that Dr. Rabi has just made, which I would like to comment on later.

I have confined my attention in this statement to the rather general overall aspects of the problem, and it is possible that what I have to say will be repeating some things that you have already had presented to you, but to just get off my chest the generalization as I see it, I would like to bring these matters to your attention.

The problem of the shortage of scientists and engineers and other technical and professional people is one of great seriousness and great importance to the welfare and security of the United States. I would like to emphasize that the problem is by its very nature a very long-range problem and cannot be solved suddenly and quickly by any miracle. Only in the highly improbable event of a very sudden and very large reduction in our defense program would we get some alleviation and even that would be only a temporary alleviation.

While the extensive needs of the defense program serve to exaggerate the current shortage of scientists and engineers, I think we should recognize that during the past half century or more the growing technological civilization in which we live has been demanding an ever and ever larger number of scientists and engineers to participate in the development and operation of the kind of American way of life that we have come to know.

The continued growth and development of this life can occur only as the result of research and development and engineering and technological work carried on by men with special talents and training.

The modern requirement that an ever larger fraction of our working force, not just more numbers, be engaged in these technological pursuits would have caught up with the supply of such talent sooner

or later even without the very large requirements of the existing d
fense program. But the defense program has advanced the day
which the demand has caught up with the supply.

I think it is well, before considering the specific remedies whi
we might look into, to see where there are various pools of manpow
or sources which might be looked to to help meet this further nee

First, there is the pool of students who are now in college. Let
take a look at them first. Of the male students now enrolled in Am
ican colleges and universities, I believe something like 20 to 25 perce
of the men are now pursuing a science or engineering course. I thi
it is unlikely that a very large number or fraction of the students w
are not pursuing such courses and are not already in college w
transfer. It is partly because they do not have the preparation, part
because their commitments are made, though there may be a few wh
are unaware of the nature and needs in the science field, and it
possible that a well-directed educational program directed towa
these nonscientists now in college would yield some dividends.

By and large, I think the present group of college students can
regarded as having their careers fixed. This means for 4 years t
yield is somewhat determined by those already in college and unive
sity life, although some alleviation might be expected.

Secondly, there are the students who are of college age but are n
in college at the present time. The students at the present mome
who are of an age to be in college but are not in college. As you kno
it is a sad fact that in the country as a whole only about 50 perce
of the young men and women of college age and of intellectual abiliti
to enable them to qualify for a college entrance or education have act
ally enrolled in institutions of higher education. Of course, this
an enormously high fraction compared to any other country in th
world or our own record in the past history. But there are still
percent untapped. I should say this percentage varies locally ver
largely. In California, considerably less than 50 percent are not
college of those competent. In other localities, the number not in co
lege is relatively greater.

Unfortunately, these people not now in college but of college age ar
probably lost to the scientific and technical pursuits also because the
have not prepared themselves for college, because they have com
mitted themselves to other jobs, or they are married and beginning
career for which a college education is not required. Some of the
have already lost 1 or 2 or 3 years of potential college service. Then
again that is a lost generation, you might say, though somewhat a mor
energetic education program directed at them might salvage a num
ber. I think this might be explored.

The third potential pool are the students in the primary and sec
ondary institutions. Here is the great supply of future scientists an
engineers since you might say that practically all of the intellectua
competent youngsters are in school, the problem of attracting a large
percentage of these into science and engineering depends upon som
of the following circumstances:

First, these students and their counselors must have ways of testing
or examining or becoming aware of their potential talents.

Secondly, they must be made aware of the opportunities and th
possibilities in the scientific and engineering professions.

Third, they must be given encouragement to take all the necessary mathematics and science courses which will test their abilities in the first place and prepare them for college level work in the second place.

Fourth, they must be given guidance and counsel and encouragement as they pursue their studies.

If I may interject here, I was shocked to see recently a letter from an assistant principal of an eighth-grade school addressed to parents of eighth-graders advising their youngsters not to take mathematics and foreign language except in special circumstances because there are hard subjects and the youngsters might be frustrated. I think that is a shocking statement to go out from an assistant principal in an important school in an important city. I think this kind of thing is happening all the time and youngsters are being discouraged from taking ninth-grade mathematics because it is too hard, and they might get frustrated. Some way we need to change the direction of this, and Dr. Rabi's suggestion might help.

Parents must be aware of the potential talents possessed by their children and must be encouraged in assisting them in desiring and attaining a higher education. Potential interest in the science field of teaching in mathematics and science is of low grade, and/or adequate courses not available, or students are discouraged from taking mathematics and science. Students must be advised on how economic barriers on their attaining a higher education can be overcome through the obtaining of scholarships and loans and other funds available for the purpose.

The factors affecting the possible increase of the fraction of students undertaking science and mathematics courses involve good teaching in mathematics and science, good counseling in the grade schools and high schools, adequate motivation of the students and the removal of economic barriers.

I would like to discuss some of these problems.

Let us take up first the problem of teaching.

One of the greatest problems and the greatest dilemmas of our present school system is that of providing good teaching in science and mathematics. As the shortage of scientists and engineers has increased the salaries paid by industry have increased and science teacher salaries have remained relatively static, there is a serious threat of an increased and widespread shortage of any teachers at all and of good teachers in particular, and in the long run decreases the supply and increases the shortage. Without teaching at the high-school level, the entire future supply of scientists and engineers is threatened. Therefore, the study of the problem of how to improve the quality of teaching and increase the number of teachers in science and mathematics, at the high-school level especially, is, in my mind, the most difficult and most important problem before the country in this field.

Unfortunately, there is no single simple solution to it. School boards must be made aware of the problem and increase their salaries as rapidly is possible. Ways and means ought to be found to break the rigidity of salary schedules and salary advances to meet this emergency situation.

Now all teachers get the same salary, just depending on the number of units they have had in college or the number of years of experience they have had, and there is no flexibility to keep a good teacher and to encourage exceptionally able youngsters to come into the field.

Schools should seek to secure the cooperation of industry and
nearby colleges who might be able to supply part-time teaching hel
In this area, certification rules for teachers often interfere with gettin
good people from industry or colleges. They have not had enou
education courses or some other technical requirement is missin
These certification rules ought to be made flexible so that one can g
industrial or college people to come in and help out with high-scho
teaching. Summer institutes for teachers in science and mathemati
can be arranged to keep teachers up to date, to convert teachers int
science and mathematics teachers and to provide stimulation an
recognition. In this instance, the National Science Foundation
undertaking a program of summer institutes.

I would endorse that program very strongly. Prizes and award
and public recognition of exceptional teaching would assist in in
creasing the stature of the teacher in the community.

Summer employment may assist in supplementing incomes. Ther
are dangers in carrying this too far, because sometimes teachers ca
get so entranced with their industrial summer jobs they stay in in
dustry. Also, you do not want to rob the teacher of the idea that hi
teaching is the most important job and the summer employment
only a subsidiary activity.

While the teacher situation in elementary and secondary schools i
most critical, there is also a growing situation of potential seriousnes
in colleges in the engineering and scientific schools. Industrial salarie
have risen more rapidly than college salaries, thus diverting man
good people out of teaching in schools and colleges.

So much for the problem of teaching. It is a complicated one an
I can think of many things that can do it or alleviate it but no singl
thing will solve the problem.

I would like to mention another field that has been neglected
namely, the use of women in science and engineering. An almos
wholly neglected source of scientists and engineers is found in th
large number of women who have some talents but find few opportu
nities for professional employment in these fields.

In Russia, a very extensive employment of women scientists an
engineers has been achieved.

We should do the same. Even though family responsibilities ma
prevent full-time employment, even part-time or irregular employmen
might be better than none.

Serious shortage in teaching at both the high-school and colleg
level might be alleviated with more adequate encouragement and em
ployment of women teachers.

Industrial employment—women go into teaching of English an
social science and other fields in the high school but there are ver
few women mathematics or science teachers. In college the opportu
nities for women are very low. In industry they have been very low.
Industrial employment, both at the professional and subprofessiona
levels could be substantially expanded.

The National Manpower Council of Columbia University is jus
publishing a book on the utilization of woman power which cover
this whole general field in the more sensible use of the talents o
women.

Another topic I would like to jump to is the effect of the risin
birthrate on this whole system. The increased birthrate in th

United States in recent years has produced a rising flood of students that are now in elementary and high schools and will soon be entering the colleges. This higher birthrate still continues, which thus assures that for 15 or 20 years in the future, if not longer, our schools and colleges will be filled with students in ever-growing numbers. If only the same fraction of the students of this increased number go into science and engineering and other technical pursuits as in the past, the absolute numbers being graduated will continuously rise. So we will have an absolute increase in the number of scientists and engineers graduating during these coming years.

This would seem to give some assurance of a gradual reduction over the years in the shortage. However, other considerations may cancel this potential again.

In the first place, the schools and colleges may be so crowded and may be so short of qualified teachers that the fraction of students who receive adequate preparation and stimulation and motivation in science and engineering may actually be reduced.

At the same time, as has been pointed out, our industrial society requires as the years go by that a substantially increasing fraction of our working population be more highly trained in the scientific and technical fields.

Therefore, we need an increasing fraction as the numbers increase. So, thus, there is a long-term increase in demand which means an actual increase in relative demand which will not be met unless there is a relative increase in the number of students selecting science and engineering courses.

So we should not be lulled into inactivity by the youngsters coming along may satisfy the shortage; they may temporarily alleviate it, but not in the long run.

In conclusion I would say that the above statement does not present all the problems in this field or give the specific and detailed proposals for remedying the situation. It is my recommendation that intensive and competent studies of this problem be undertaken by suitable agencies and careful, competent, and thoughtful consideration be given to the proposal of a suitable program for action. No single panacea is available. No single stroke of genius can solve the problem. But a coordinated and extensive and carefully planned program of action is required and might be effective.

I would like to endorse the suggestion made by Dr. Rabi that to stimulate the teaching and taking of mathematics by high school students by scholarships is excellent, and which would go to the heart of this problem of encouraging parents and students and teachers to stimulate students to take mathematics in high school.

That is the end of my formal remarks.

Representative PRICE. Mr. Hinshaw, have you any questions?

Representative HINSHAW. I think it is a very fine statement.

When we were discussing this subject with Dr. Wolfle, I noted that he was quite interested in the curricula that were being offered in the high schools, and particularly in the high schools, and the character of available teaching staff.

I wonder if you would agree with me in the suggestion that the scientific profession—certainly those who are available for it—should become more and more interested in taking positions on school boards

and running for office, so to speak? That is the way they can effect it, and effect it in a way which they believe to be the best.

There are other groups who are very much interested in the curricula of the schools and they will have their people run for office.

As you well know, and as I know with a common experience, there are not very many people who have the qualifications of an educator who are willing to run for the school board positions. They are either chambers of commerce people or parent-teachers' association people or something of that sort.

Dr. DuBridge. Those are usually the best ones.

Representative Hinshaw. They are usually the best ones but they are not necessarily the best qualified to prescribe the course of instruction that should be given in the secondary schools to qualify students for further education in the scientific fields.

I would like to know what you think about it.

Dr. DuBridge. I think that one cannot help but agree that getting more qualified people on school boards would be an enormous help. You and I know of many districts in California where qualified people on the school boards do not seem to exist or at least are not in control. There is a very serious situation. Whether the school board is the most critical and most effective level at which to effect your curricula is another question.

The high-school teachers and principals and administrators are presumably the experts on the curricula. If there are going to be curriculum changes, they will have to at least support them and usually recommend them and work them out. So, for the school board to insist to the principal or the superintendent that he give more mathematics may be hard to enforce if the superintendent himself does not believe in more mathematics or if he can't get the teachers for it. Here is a problem of penetrating into the teacher training and the teacher attitudes so that the teachers themselves will try to develop better programs in the mathematics field.

I am certainly not opposed to having first rate people, including college people, on school boards. The wife of one of our professors tried to run a few years ago and she was soundly beaten. She would have been an excellent member.

People are suspicious of college professors and their wives. So this attempt didn't work.

One of our professors, however, was on the school board, as you recall, and was doing a good job until the State government grabbed him away for another job.

Yes, I am in favor of better competence on the school board, but I think curricular problems must be solved by the schoolteacher.

Representative Hinshaw. In the suggestion that Dr. Rabi just made in giving a prize, reward, or grant to those who are able to pass a certain examination in mathematics, of course the degree of difficulty of the examination would have a great deal to do with the degree of excellence of the teaching that was necessary for a youth or girl to achieve that award.

While I do not know all there is to know about teaching at the lower schools and the curricula in the lower schools, I do recognize that there are at least two schools of thought as to what that should be. There are two methodologies proposed. I believe one of them is separated

from the rest by being called the progressive system of education. I believe, although I cannot say I have much knowledge of it, that that is a system which promotes the child whether or not the child has achieved a given degree of excellence in the studies that he is engaged in and that the child also has a certain selective choice as to what subjects he will take or not take. Just as this letter you were talking about discouraged the child from taking mathematics in the ninth grade because it might be too much exercise for him, that sort of thing has persisted in California schools to a certain extent and is reflected, I can tell you, in the number of people who pass the examinations for qualification for entrance to the Military and Naval Academies. It has been quite noticeable in my own district in California as to the difference between those who took the examinations from one set of schools or from another.

Who is going to set up the examination? Are we going to leave it up to the Board of Examiners for the Military or Naval Academies, or are we going to leave it up to the National Education Association, or the Health, Education, and Welfare Department, or who is going to set it up? Depending upon who sets it up and the type of thinking that motivates that agency, will depend the degree of excellence achieved in the schools.

Dr. DuBridge. You put your finger on a very difficult point. The exam should not be so hard that it discourages students, but it must not be so easy so that we do not get qualified students. Therefore, it might be stiffened up slightly over the years to lead the schools on to a better standard of teaching. However, there is an agency which is quite competent to do this job without being biased too much in any direction, and that is the College Entrance Examination Board and the Educational Testing Service.

The College Entrance Examination Board gives now entrance examinations to hundreds of thousands of high-school seniors throughout the country and a very large fraction of the country that have selective administration use the college board exams as the basis for their admission.

At Cal Tech, we take the College Entrance Examination Board scores as the most important single criterion for qualification for admission.

The National Merit Scholarship Foundation, which is just getting started this year and has just awarded its first scholarships—some by industry and the Ford Foundation—has used the College Entrance Examination Board and the Educational Testing Service to prepare their examination for qualifications for these scholarships. I think there is an agency which is neutral and private but which can undertake this job of providing the proper level of examinations to meet the requirements of this suggestion.

Incidentally, I would like to make one slight amendment in Dr. Rabi's suggestion. I think the examinations ought to be such as to give a person the option of taking either calculus or solid geometry in high school. Certain high schools are beginning to offer elementary calculus instead of solid geometry. I personally think this was a good move.

Representative Hinshaw. Dr. Rabi suggested calculus in the first year of college.

Dr. DuBridge. Yes. But there a few high schools that are offering it. I was at a meeting just last week in southern California on a discussion of high-school courses in calculus. I think, myself, it would be a good move to have students have the option of taking either solid geometry or calculus in their senior year of high school. I would not like to discourage this tendency of giving that option in high schools.

In addition, after the youngster has completed his first year in college, to allow him to take a calculus examination or maybe some other field of advanced mathematics which he could take in college to qualify for a second year of college.

Representative Hinshaw. Where does analytical geometry come in?

Dr. DuBridge. Analytical geometry and calculus generally come along together.

The illusion that calculus is so tough that only Einsteins can take it is dangerous. It is too bad that so many people around the country have the idea that calculus is only for Einstein. It is false.

It is basic and fundamentally simple.

Representative Hinshaw. It is entirely within the competence of a very young man.

Dr. DuBridge. That is right.

Representative Durham. Dr. DuBridge, I notice you made the statement that 25 percent of the precollege group were taking science courses.

Dr. DuBridge. Boys.

Representative Durham. How does that compare with former years?

Dr. DuBridge. I am afraid I don't have the figures on that. I think it is probably a smaller fraction than it was many years ago, let us say 30 or 40 years ago, but a possibly larger fraction than it was 10 years ago. I am sorry I do not have the exact figures on that. Maybe Mr. Wolfle might have them.

Representative Durham. That is all, Mr. Chairman.

Representative Price. Thank you very much, Dr. DuBridge. We enjoyed your fine statement.

The committee will stand in recess until 10 a. m. on Wednesday, April 25, at which time Gen. David Sarnoff and other witnesses will appear to continue testimony on the shortage of scientific and technically trained manpower.

(Whereupon, at 12:45 p. m., Thursday, April 19, 1956, the hearing was recessed until 10 a. m., Wednesday, April 25, 1956.)

SHORTAGE OF SCIENTIFIC AND ENGINEERING MANPOWER

WEDNESDAY, APRIL 25, 1956

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
SUBCOMMITTEE ON RESEARCH AND DEVELOPMENT,
Washington, D. C.

The subcommittee met at 10 a. m., pursuant to recess, in room 1334, New House Office Building, Hon. Melvin Price (chairman of the subcommittee) presiding.

Present: Senators Anderson, Jackson, and Pastore; Representatives Price, Hinshaw, Durham, and Patterson.

Present also: George E. Brown, Jr., of the committee staff.

Representative PRICE. The committee will be in order.

This is a continuation of hearings of the Research and Development Subcommittee of the Joint Committee on Atomic Energy, on the problem of the shortage of scientific and engineering manpower, particularly as it affects the atomic-energy program.

During the past week we have heard many witnesses from scientific organizations and from the Atomic Energy Commission. Today we are privileged to have as our first witness Gen. David Sarnoff of the Radio Corporation of America.

General Sarnoff, would you come around, please.

General, I understand that you have a prepared statement.

STATEMENT OF GEN. DAVID SARNOFF, RADIO CORPORATION OF AMERICA

General SARNOFF. Yes, sir.

Representative PRICE. We are pleased to have your statement, and then we hope you will allow yourself to be questioned.

General SARNOFF. Yes, sir; I will be very pleased to.

Representative PRICE. Will you proceed?

General SARNOFF. Mr. Chairman and members of the committee, permit me to congratulate your Subcommittee on Research and Development, and its able chairman, the Honorable Melvin Price, upon your initiative in undertaking an earnest inquiry into the problem of scientific and technological manpower. I fully share your concern in this area, and therefore consider it a privilege to appear here today.

The existence of the problem is by this time fairly common knowledge. There has been no dearth of warnings about the shortage of trained men for our vast and ever-growing industrial complex.

What is needed, however, is a thorough examination of the whole field, including a systematic collation and appraisal of suggested solu-

tions as a basis for recommending practical action. This, as I see it, is the heavy assignment shouldered by your subcommittee, and it can count, I feel confident, on the understanding and cooperation of industrial, educational, and military leaders.

An important byproduct of the inquiry, of course, should be a clearer appreciation by the American people as a whole of the dimensions and urgency of the problem. Under our way of life, an enlightened and sympathetic public opinion is indispensable in attacking and surmounting major challenges. This is especially true where, in Congressman Price's words, "the emphasis must be on Federal leadership," because "only the Federal Government has the resources and prestige" required for adequate and effective action.

American security and industrial strength—two goals which are completely intermeshed—are today dependent upon our success in overcoming present shortages and assuring an expanded reservoir of scientists and physicists, trained engineers and technicians. This hardly needs to be proved, it is so self-evident. There is no substitute for brains and practical skills in a technical age like ours. Automation, it is true, is advancing with giant steps. But every step, if it is not to turn into a stumble, demands additional contingents of qualified personnel.

The best machines and weapons are worthless if there are not enough competent men to operate them. What is more, neither machines nor weapons will long remain the best unless research and development are maintained at a high level and dynamic tempo, which in turn calls for a constant accretion of specialized personnel.

Science and technology have long been the hallmarks of our American civilization. Throughout the world, our industrial and technical progress is described as Americanization. American supremacy in these fields is historic.

It is extremely disturbing, therefore, to learn that Soviet Russia is already turning out engineers at a greater rate than we do. It comes as a shock to be told that if the present trend continues, the land of communism will, within a decade or sooner, outstrip the United States across the technological board. In the struggle between freedom and communism now underway, this is a situation that we cannot afford to view complacently.

I skip the supporting statistics. These will no doubt be developed in other testimony. Besides, your subcommittee has already done a necessary and splendid job in collecting and publishing, just last month, the basic facts on Engineering and Scientific Manpower in the United States, Western Europe, and Soviet Russia. Those facts leave us little margin for smugness.

Of course, a police state can and does compel its youth to enter careers of its own choosing. It conscripts minds as ruthlessly as it conscripts bodies. That kind of regimentation, thank God, is ruled out in our country. Other methods, wholly within the framework of our cherished freedom of choice, must be developed and put to work.

We must not let our natural revulsion against the fallacies and the crimes of communism and its dictators lead us to underrate the capacities and abilities of the Russian people. Their youth are made to feel it is their patriotic duty to study and acquire knowledge and skill in the fields of science and technology. The Soviet Government

even goes so far as to extend special privileges to its scientists and engineers.

In America, science and technology have long been so all-pervasive, so familiar, that they are taken for granted. Some of the aura of excitement and adventure which surrounded them in an earlier period has begun to fade out.

We must rekindle in our youth that sense of adventure in pushing forward the horizons of science, research, and invention. They must be helped to feel the thrill of delving into the mysteries of chemistry and physics, of electronics, atomics, and aerodynamics. They must be made conscious of wonderful scientific worlds to be explored, mapped, and opened up for the good of all mankind.

That task belongs primarily to the schools. But parents, industry, the press, and social organizations can play a vital role.

Despite the many opportunities for gainful employment in the technical fields available and widely advertised—the fact is that not enough young Americans are taking up scientific careers. Why? Many guesses have been made. But it is vitally necessary that concrete knowledge replace guesswork on this score. Why should not these young Americans themselves be questioned on that subject? It seems to me that a survey or poll of students in the senior year of high school and the freshman year of college—the critical years of career decisions—might well provide information helpful in drawing more qualified people into engineering and related fields.

Our economy and our national safety alike will suffer seriously unless we act now and vigorously to solve the urgent problem of technical manpower. The immediate lack—already an embarrassment to large and small companies—will not cure itself. The diagnosis must be made and the therapy prescribed.

Long-term treatment is essential; but interim measures, short-term remedies, are also vital. The recommendations I should like, with your permission, to put on record today are in that short-term category. They are not presented as cure-alls, but simply as measures that could go a long way toward ameliorating the present critical situation.

The current shortage of teachers in scientific and technical subjects is generally recognized as one of the immediate problems. Several months ago, at a dinner of the National Security Industrial Association held in Washington, D. C., I proposed the establishment of what I described as a "national educational reserve." It would comprise qualified teachers of mathematics, physics, chemistry, engineering, and related subjects, to be drawn from the ranks of industrial technology.

I suggested that industry release—with full pay, for at least 1 year—a reasonable number of men and women for teaching assignments in nearby educational institutions, particularly the upper grades in high school. This unique reserve could also mobilize persons who have reached the retirement age in the military service and in industry, but whose experience and knowledge would make them competent and inspiring teachers. It could take in, also, qualified people willing to teach in night schools without taking leave from their industry jobs.

The number of teachers furnished by any single company would be too small to entail hardships for the plants, offices, and laboratories from which they are detached. But, if drawn from a wide list of organizations, it could be large enough to give new impetus to the

teaching of sciences in our school system. This would be especially true at the high-school level, which is at present the tightest bottleneck.

I envisage this educational reserve, of course, as a temporary expedient, let us say for 5 years, to help meet the immediate need, while more permanent solutions are being worked out. Moreover, whether the initiative is taken by industry or Government or, as would be more likely, by both, the plan itself would naturally be drawn with the consent and cooperation of school authorities, who would prescribe the courses and regulate the instruction.

As we all know, many men and women who normally would have become teachers of the sciences have gone instead into industry, where the economic rewards are more attractive. The fact that teachers are generally underpaid, that many of them can do better in private jobs, enters into the equation of teacher shortages and must be remedied. That aspect, too, I hope, will be covered in the course of this inquiry.

Meanwhile, it is a fact that industry has siphoned off some personnel from the educational system. It would seem to be industry's obligation to recognize this fact. But, obligation aside, industry would be well advised, as a matter of clear self-interest, to help replenish the reservoir of trained manpower by stimulating relevant studies at all educational levels. Its current hunger for engineers and other specialists will turn into a serious famine if existing conditions are not quickly improved. Industry must take a leaf from farsighted conservationists, who plant two trees for every tree they cut down.

I am quite confident that, in the main, industry will cooperate with an educational reserve. The public is not fully aware of the extent to which corporations today are providing scholarships, fellowships, and other inducements to promote the study of engineering and science. Some of them, in addition, are contributing funds to help maintain or enlarge educational institutions related to their particular field of enterprise. The Radio Corporation of America, I am pleased to be able to say, has been among the pioneers in such endeavors. All of which attests, if any proof were needed, that industry is in a mood to support any practical undertaking likely to increase the flow of trained manpower into its ranks.

The teachers in the proposed educational reserve would obviously be persons with backgrounds of practical experience. Thus they could bring into the classroom the breath-of-living reality. They would help to stimulate that sense of adventure in technical careers to which I have already alluded. They would inspire many an able and imaginative student to follow the scientific and technological disciplines into the college years. Enthusiasm is contagious.

To make the project attractive, teachers enrolled in the reserve should be given recognition and status through membership in an organization somewhat similar to the various national military reserves. I believe it should be set up on a national scale, perhaps by an act of Congress, with membership carrying appropriate titles, diplomas, and the like. The educational reservists would thus be recognized, and rightly so, as a vital element in the equation of national security.

I have presented this concept in broad terms. There may be flaws in it which a detailed formulation could correct. Since its presen-

tation the response to the proposal from many quarters has been impressively favorable. I trust that we can move ahead without undue delay, because each passing day makes our problem more difficult.

It is the unique nature of science that the more it accomplishes, the more remains to be accomplished. Every new invention or discovery, far from narrowing down the perspective, opens up exciting new horizons of exploration. Science, of which engineering is a part, is never static or finished. Its every achievement marks a new beginning. Though rooted in the past, its thinking and its mood are ever geared to the future.

In attacking the problem of manpower, we must therefore also gear our planning to the future. Nuclear energy, as the most recent development, with almost limitless prospects of growth and useful application, necessarily plays a large role in the planning. The awesome destructive aspects of this new force in our lives are overdramatized, to the point where its beneficent potentials are obscured.

We must bring home to the youth of the Nation the truth that nuclear energy is essentially a force for good, capable of creating a world of abundance to match men's most optimistic dreams. With this in mind, I wish to make another recommendation.

To signalize the importance of the scientist, the physicist, the engineer, the man of technology in the dawning age of nuclear power, I suggest the construction of atomic reactors on the campuses of a selected and limited number of American colleges and universities. This step would serve many purposes directly and indirectly in line with the attainment of the goals we seek.

These reactors would operate to stimulate the interest of students in matters scientific. They would help to enhance the prestige of the phyical science departments of the various schools involved. These factors in turn would help to build up the enrollment of young people in the technical fields.

The presence of the reactor would provide a living laboratory, to heighten the realism of instruction. It would enable the student to get a glimpse of his own role in the nuclear future. Under the guidance of competent teachers, it would stir him to visions of applying this force for constructive purposes. The impact on the student, in short, would be at once inspirational and practical.

Incidentally, each reactor could be utilized to furnish power for the operation of the college or university where it is located. In this way the actual or prospective science student would not only have the possibility of working on a reactor in being, but would be permitted to see nuclear energy in its peaceful use.

Gentlemen, to insure the continuation of technological progress in our country, to guarantee American security, we must solve the problem of specialized manpower. We must, without further delay, devise and implement means of attracting ever-increasing numbers of our ablest young men and women to scientific studies. Every new student carries the possibility of important contributions to science, research, and invention. We must nourish that possibility and encourage its expression.

Experience has taught that the beginnings of our progress as individuals and as a nation have often been found in tiny seeds. The steam engine was born in a tea kettle: the airplane came out of a bicycle shop; the automobile first sputtered and moved in a small

carriage shop; and broadcasting started from an amateur station in a private garage. Today, the architects of our future are largely the young people in our schools. We must stimulate their vision of achievement and open to them the paths to its realization.

The problem of adequate trained manpower, underlined for us by the progress in Soviet Russia, must be met promptly and with full recognition of its immediacy and urgency. I am convinced that if all of us face up to the challenge now, America can solve this problem and maintain our leadership in science and technology.

Representative PRICE. We thank you for a very fine statement. The Chair has assured Senator Jackson, who has another committee to preside over shortly, that we will hear from him at this time.

Senator JACKSON. Thank you, Mr. Chairman.

First, I want to commend you and your subcommittee for the fine job you are doing in bringing out the facts with reference to the engineering and scientific manpower shortage in the United States in comparison with our potential enemy.

General, I want to congratulate you on your very fine statement. I was particularly impressed with the two basic suggestions—one, the manpower reserve that you have brought forth, which I think is an excellent suggestion, and one which should be given serious consideration, and two, with reference to the construction of power reactors and research reactors on college campuses.

I have been impressed very much by your suggestion in this regard. We have a situation in my own State of Washington at two of our colleges that come within your comments. One is that the University of Washington is about to replace its own powerplant. They are ready with a million dollars to build a powerplant but they would like to have a nuclear powerplant which will supply the power for the university and provide research. We have the same thing at Washington State College in a little different way, where they want a research reactor.

I have introduced a bill, Mr. Chairman, that carries out the suggestions that have been referred to.

Representative PRICE. In testimony before the subcommittee last week, the Atomic Energy Commission, represented at the time by Dr. Libby, announced that the Commission is recommending a new program that will permit the reactor program to be taken to the campuses of almost every university in the country. They were a little limited in what they proposed before the subcommittee, but by the time the hearing was over, they indicated they would not place any limitations on the program.

Senator JACKSON. The program up to now has been one to supply fuel only. What is needed, of course, is some assistance in the construction of the reactor.

Representative PRICE. That is part of a new program which they first brought to light in testimony before this committee last week.

Senator JACKSON. I appreciate that. I introduced this bill on April 12 with the idea of getting the Commission to move. I do not know whether they have the authority or not. I think they claim they have.

Representative PRICE. They need additional authority which they say they are going to request.

Senator JACKSON. I think this amendment, S. 3621, will give them that authority. You feel if legislation is needed we should have it in the field with reference to reactors, General?

General SARNOFF. Yes, sir; I do. I think it would be an excellent way to advance the purpose.

Senator JACKSON. Mr. Chairman, I would like to make this observation on the importance of going forward on these research programs and providing grants. The University of Washington received from the Guggenheim Foundation back in the 1920's money to set up a school of aeronautical engineering. The amazing result of that investment can be found in the design of the B–17, the B–29, the B–47, and the B–52. The creative ability came from the University of Washington School of Aeronautical Engineering that stemmed from the Guggenheim grant away back in the 1920's.

Unfortunately, only a few schools, General, were able to get those funds. I think that is an outstanding example of where an investment of that kind will pay off in national security in years ahead.

I want to commend you for those two very important contributions. I was particularly interested in this question of dealing with the subject of nuclear power reactors that can be used for producing usable power and also for purposes of research. I want to thank you, Mr. Chairman, very much.

Representative PRICE. Are there any other questions? Senator Anderson?

Senator ANDERSON. Like Senator Jackson, I have an Indian Affairs Committee going on that is waiting for me, and a Finance Committee meeting that I promised to get to.

Do we not have a problem, General, as to whether we try to have more reactors of a research type or relatively few reactors of the power type? You build a research reactor, and it is well under a million dollars. You go into a power reactor, and while we have had figures of $3½ million, I think the one on the coast is relatively small, and they started with $5 million, and ended closer to $10 million. If it gets to figures like that, very few of them can be built. Do you think we better try to keep to the research type for a while before we get into the power type?

General SARNOFF. Senator, my emphasis was on the research end of it. I think you might have 1 or 2 power reactors to see how they work and to give the young people an opportunity to see the end result. But, basically, the research reactor would meet the major problem I have in mind at this time, because you can't take a field like atomic energy, difficult and complex as it is, and translate it altogether into words and figures. You have to show something that moves and lives and does something.

Senator ANDERSON. I agree with you and I am glad to have you say that. You may come to a choice. You may have to decide whether you want more research reactors at more campuses or a relatively small number of power reactors at a few institutions where there is already a fair opportunity to acquire needed information.

General SARNOFF. Yes, sir. I think that would be a matter of experience. The major objective I have in mind in the recommendation is not the furnishing of power, but the furnishing of visible and tangi-

ble evidence of the operation of a reactor so that the studies of the students would be advanced. If, incidentally, you can also furnish local power for the university or college, that is so much to the good.

Senator ANDERSON. The power is likely to run 50 to 60 mills as against the much cheaper cost from other sources. I think we do need some work in that field. It seems to me that the Army design of some small reactors that they hope to use along the DEW line might afford an opportuntiy to test these out in educational institutions, and that would be in line with your suggestion. I think that might be helpful in what you have in mind here.

General SARNOFF. Yes, sir.

Senator ANDERSON. I am very happy to have you suggest the use of a reserve in this Nation. You are probably very familiar with the fact that the people who are in this field are siphoning off science teachers pretty rapidly. A short time ago I had occasion to talk to the school administrators in Denver at their meeting, and they came up to me and said, "It was not very many years ago that the oil companies robbed the colleges of their science teachers. Now the uranium companies are robbing the colleges and the high schools." I do not know where they expect to find the future scientists to come from under those circumstances. This man is a science teacher in an oil community. He knew a little bit about oil. The oil company came and said, "Would you like to join us? We can tell you the circumstances. You write down your salary, and if you multiply it by 2, you can figure out what your starting salary with us will be." That is pretty tough on the school system.

General SARNOFF. Sir, I have frankly stated in my opening remarks that there has been that siphoning off, but I am not disposed to be critical of what has taken place, because this situation is intermeshed. On the one hand industry, faced with the problem of advancing on these technological fields, primarily for Government defense work and so on, has got to have the men it wants. If it does not have them, then it does not fulfill the Government objective in the defense area.

Also industry has been doing a great deal, as I have intimated, to help the colleges by grants, contributions, lectures, and other means, so it has been working both ways. But it is not working sufficiently, and it is not wide enough to give us the answer that we require.

Also, there is the fact that schoolteachers, being human, are attracted by greater opportunities. I think we ought to make the life of the schoolteacher and the college instructor a little more attractive where he is. But at the moment, we do have in the country sufficient knowledge, whether it be in the minds of people in industry or those in universities, to go forward with the urgent problem that faces us. What I am recommending, of course, is not a normal or permanent solution. But it is a suggestion to meet what I regard to be, and as you gentlemen do, I am sure, a real urgent matter.

Only 2 or 3 days ago, Mr. Dulles of the CIA made an address before the University of Cincinnati, on the 20th of April, and he said, if I may quote:

> In my work as the Director of the Central Intelligence Agency, I have the problem of gathering together from all intelligence sources available, both here and abroad, the facts and figures on the Soviet economy ,and then getting the most competent experts available in and out of Government, not only those in the CIA itself, to examine and analyze these facts and figures. In general, this

examination has led me to the conclusion that the only safe position to take is that in the technical, engineering, and industrial fields, the Soviets can achieve any particular objective we can achieve. Of course, they do copy us. In some fields they are doing pioneering work on their own. Those who assume that we have superior technical skills that we could produce atomic weapons, aircraft, and the like, which are beyond the competence of the Soviet, have generally proved to be mistaken. Certainly in recent years I have not proceeded on any such assumption. The Soviets have shown high competence in the field of nuclear development, both for military and peaceful purposes. They have produced highly efficient aircraft, from heavy bombers to helicopters. They are highly competent in the field of electronics. Their steel industry is efficient, and the same is true generally across the board in the industrial field. Where we particularly excel is in our highly competent manpower and in the efficient use we make of it, particularly through the incentives our society provides to call forth individual effort.

It is that incentive and that individual effort and that increased manpower that I am recommending we do everything we can to advance.

Senator ANDERSON. I think it is a fine recommendation, General. I am very happy that you as a leading industrialist, are making it, because if some of the rest of us make it, they say industry is not going to make the people available. There is in Washington the Arlington plan where people of the community have tried to find individuals who can go into the schools and stir up the interest in these youngsters in physics, mathematics, and chemistry, that I think need tremendous emphasis at the present time.

I am not going to lecture, but we know the time when ministry and medicine and law were the 3 great professions open to the youngsters and probably the 3 greatest, and while they are still 3 great professions, this country badly needs the chemists and physicists and mathematicians. Anything that industry can do will be helpful.

Certainly the emphasis given it by a man in your position is going to be useful to this country. I am very happy that you are making this recommendation. I appreciate it very much.

General SARNOFF. Thank you, sir.

Representative PRICE. Mr. Hinshaw.

Representative HINSHAW. I am very much interested in the suggestion you made, General, concerning educational reserves and persons in industry who might be competent to teach at presumably the high-school level. Unfortunately, in many States from the standpoint of establishing this reserve, there is a requirement that persons who are to teach in the schools must have a teacher's certificate and pass the examinations that are necessary to acquire that certificate and have certain experience in teaching. I think in other States that do not have the requirement, necessarily, it might work very well.

There was a suggestion made by Dr. Rabi to this committee the other day which I would like to have you comment upon. Dr. Rabi, of Columbia University, a member of the General Advisory Committee to the Atomic Energy Commission, suggested that we offer Federal prizes or grants of $500 each to all students of the high-school graduating level who could pass a given examination—the same examination all over the United States—in mathematics. He spoke of mathematics as being the neutral scientific subject. It is common, he said, to all science, and even to the law, as a matter of fact, and other professions. I think he said that it is the common denominator of practically all of the professions. An examination in plane and solid

geometry, algebra, trigonometry, and perhaps in time, in differential calculus. In that way, he said, it would stimulate not only the student to study mathematics, but it would stimulate the teachers, boards of education, superintendents, and that sort of personnel, to a competition as to what proportion of their graduating students from high school might pass such an examination, or might be prepared to pass such an examination, thereby stimulating the teaching profession too.

Then, of course, the entrance into college would be thereby facilitated with cash. They need or need not enter college as a requisite, but probably not.

That is a brandnew thought to you, too, as it was when we heard it, and the estimate of the cost was something like 25 or 50 million dollars a year over the whole United States, and I would like to have your comments.

General SARNOFF. Sir, it is a new thought. This is the first time I heard about it. Therefore, my comments are not the result of thought, but merely my initial reaction to the suggestion. In principle, I would favor the idea. Dr. Rabi is a man of high scientific attainments himself, and is a thoughtful type of individual; I am sure that he thought it through before he made the suggestion.

My offhand reaction, however, is that while it is true that mathematics is the basis of practically all science, nevertheless that is not all there is to science. It is natural for Professor Rabi, who is himself a great mathematician, to place the greatest emphasis upon mathematics. But each of us, you know, is likely to place the greatest emphasis on the particular thing in which we happen to be expert.

Representative HINSHAW. I might say, General Sarnoff, Dr. DuBridge was also present, I think a very considerable physicist, and he concurred with Dr. Rabi.

General SARNOFF. I was about to say that while I am certainly in favor of the principle, and the idea of stimulation, I would like to see it broadened out a little so as to include physics and chemistry and not limited necessarily to one subject of mathematics. These are a number of people who are experts in mathematics, and who have never translated their expert knowledge into anything that is practical.

I do not think that the idea would suffer if it were broadened out a little to include a wider area of stimulation for general scientific matter.

As to investment, my feeling is that with the heavy investments we are making in machines, we cannot regard additional investments in men as wasteful or unnecessary, because the machine without the man is not any good. It is certainly worthwhile to make whatever investment can reasonably be made to stimulate a national interest in science.

On the whole, I would favor that idea with some amplification of the area.

Representative HINSHAW. I might mention that it has been reported to this committee that the physics and chemistry teachers who are qualified to teach at the high school level have practically all been siphoned off from the school system into industry. For example, in the Pittsburgh area, where there are 43 high schools, there are, I think, 3 qualified physics teachers. Therefore, it is not possible to do the thing that you said. But there are some mathematics teachers still available.

General SARNOFF. Of course, that is an added reason for adopting some emergency measures to meet that shortage.

Representative HINSHAW. The reason why Dr. Rabi suggested that mathematics teaching and examination was because when the student reaches the senior year in high school or freshman year in college, he must already have had a basis of mathematics to make a decision as to whether or not he wanted to enter upon a scientific career. You mentioned the senior in high school and the freshman in college as the point of decision.

General SARNOFF. Yes.

Representative HINSHAW. But that point of decision can't be reached if there is no teaching of mathematics.

General SARNOFF. That is true.

Representative HINSHAW. I mean if there has been no teaching of mathematics.

General SARNOFF. That is true.

Representative HINSHAW. Therefore, Dr. Rabi was urging a stimulation of mathematics all through the high schools by this means. It would be a subsidy to education. It would be a subsidy to the educated.

Representative PRICE. General Sarnoff, the question of including physics and chemistry was brought up at the meeting. I propounded it to Dr. Rabi myself. They wanted it specifically removed, because they thought that would bring it into the field of specialization. Mathematics was a more neutral approach, and would be open to every student without any regard to what his plans were in future life. So you would not have a discriminatory program to start with. This would be open to every student in the United States, regardless of what his future plans might be. They felt that if you brought in subjects like physics and chemistry, you would immediately start to narrow it down and make it appear to be open only to those who planned scientific and engineering careers.

General SARNOFF. When men like Professor Rabi and Dr. DuBridge make a recommendation, I would be more influenced by their judgment than I would be by my own offhand reaction, because these are men who know their subject thoroughly. I simply thought it might be extended. If they have considered it, and thought it out, and believe that the end result would be better secured by limiting it to mathematics, I would be inclined to go along with their view. They are educators of the highest class.

Representative HINSHAW. Dr. Libby did mention a program that will be supplying noncritical quantities of material which would cost the Commission approximately $250,000 a kit. That would have to be housed and certain instrumentation provided by the university. It would provide a very good beginning in the operation of reactors and nuclear physics.

That is all.

Representative DURHAM. General Sarnoff, your statement is very stimulating to me. Of course, we have in this committee realized this problem, I think, probably longer and more seriously than any other committee on Capitol Hill. Your statement suggesting that these teachers be assigned from industry back to the teaching level—although you did not say so—that would apply to the high school level as well as the college?

General SARNOFF. I had particular reference to the high school level, because that is where the bottleneck is tightest at this time.

Representative DURHAM. You feel that is the place to start?

General SARNOFF. Yes, sir.

Representative DURHAM. With an all-out effort?

General SARNOFF. That is the most important place to start out now, sir.

Representative DURHAM. You suggested, I believe also that industry pay these teachers, is that correct?

General SARNOFF. That is my suggestion, yes, sir.

Representative DURHAM. I believe that to be an excellent idea and I believe we could probably get something going in the high school level where it is in my opinion the most serious.

General SARNOFF. If I may supplement, sir, I am not recommending that industry be compelled to do this. I am recommending a voluntary effort. While I do not speak for all of industry, speaking for my own company and others with whom I have discussed it, I feel sure that industry would respond as a voluntary and patriotic effort.

Representative DURHAM. I believe you said you had good response to it so far. Is there any concerted effort to put the idea before industry throughout the country?

General SARNOFF. No, sir. There has been no concerted effort because I made the suggestion only a few months ago before the Forrestal Memorial Award Dinner. I took no action beyond that. I wanted to see what the response was. I do not know that any one person in industry can do it. It seems to me that the initiative for this should come from the Government and from a committee such as yours. The establishment of a National Education Reserve calls for governmental action.

Representative DURHAM. Of course, industry primarily up to the present time has concentrated its scholarship program in the colleges throughout the country. Have you given any thought to the establishment of a scholarship at the high school level by industry? Was that in your mind?

General SARNOFF. Yes, sir; I would broaden out the scholarships to include high schools. I do not think that industry, in furnishing these men as teachers, should or would discontinue the assistance to colleges and other institutions that they have been rendering in the past.

You need to build up some kind of agency or organization or instrumentality where this would be concentrated. You cannot make it everybody's job. Also, there ought to be a close study and relationship with the educators because the actual teaching should be under the control of the educators. The point that was brought up here before about licenses and so forth, there will be any number of these subjects and items that will call for attention. This is not anything but a rough, broad outline of an idea. This is not a specific program for implementation.

Representative DURHAM. What disturbs be as an individual—and I have lived in a college community all my life—is the fact that probably at this time this program of scholarships, whatever it is, has not met the desired need and is not meeting it today. So in my opinion we have to attack this from some other point.

General SARNOFF. That is quite right.

Representative DURHAM. The program that has been intiated primarily to supply atomic people who have some knowledge of running reactors has been in progress not at a high scale. But certainly we have had a program of training in reactors since 1948 and 1949. We have in being today a reactor on a college campus.

Mr. Chairman, I would like to at this point suggest that the committee get the results obtained by turning out nuclear physicists and scientific personnel, which is a matter of record, and place it in this record. That is direct evidence, in my opinion, of what has been accomplished so far in one place. It has been in operation about 5 years. I think it would be very enlightening not only to the committee but to the country.

Representative PRICE. Without objection, the request is agreed to.

(The following information was supplied by J. H. Lampe, dean of engineering, North Carolina State College:)

NORTH CAROLINA STATE COLLEGE OF THE
UNIVERSITY OF NORTH CAROLINA,
Raleigh, N. C., June 2, 1956.

Hon. CARL T. DURHAM,
Joint Committee on Atomic Energy,
Congressional Office Building, Washington, D. C.

DEAR MR. DURHAM: Your telephone request of yesterday came during an extremely busy period which included the last day of examinations and a conference with industrial leaders of North Carolina as to our engineering training program. I am very happy that you talked with Dr. A. C. Menius, head of our physics department, and he joins me in sending information you requested concerning our training program in engineering physics and nuclear engineering.

The nuclear-engineering program, which includes undergraduate and graduate work, is an integrated operation in the school of engineering at the present and is administered by our physics department. This program was started in June 1950, and to date we have graduated the following men in nuclear engineering: 70 bachelor of science, 74 master of science, and 2 doctor of philosophy.

Our graduates are in great demand by industry, Government agencies, and the armed services. One of our major problems is how to "feed back" some of our graduates into the teaching work in order to carry on this effective and critically needed educational program in nuclear engineering. The large salaries offered to our bachelor and especially our master graduates simply remove teaching positions (with relatively low salaries) from competing for our graduates' services.

Our present enrollment in nuclear engineering and engineering physics is as follows: 62 freshmen, 54 sophomores, 29 juniors, 15 seniors, 37 master of science, and 2 doctor of philosophy.

In addition to this enrollment, we continually provide indoctrination and fundamental instruction through noncredit short courses. Typical of these operations are the following:

1. We are participating in the Argonne School instruction for students from foreign countries and from the United States. This is an Atomic Energy Commission-supported short course of 32 weeks which is operating through the International Cooperative Administration in behalf of atoms for peace. Our first program started on April 16 and we have enrolled at the present time 32 students, 23 from many foreign countries and 9 from the United States.

These men will spend the first 16 weeks of the program here at North Carolina State College and the second 16 weeks at the Argonne National Laboratories in Illinois. (Penn State is offering a parallel short course of this type.)

2. Starting last summer we had here in the engineering school a 4-week short course for representatives from industry in the United States. This of course proved to be very effective and helpful and we had 43 to participate. We now look forward to a second short course of this type to be held in Raleigh in July with approximately 45 participating. I am enclosing a brochure describing this course. We have received encouragement and informational help by the Atomic Energy Commission and the course has been operated entirely on the tuition fees collected.

3. From time to time we have given short courses on a local basis for industries, particularly power companies plus some others, on general information and activity in the field of nuclear engineering.

As a part of our educational endeavor and with State and local industrial support we put a small 10-kilowatt water boiler (homogeneous) reactor into operation in September 1953. This reactor and its associated building and laboratories represent an expenditure of approximately $630,000. We of course worked closely with the Atomic Energy Commission through channels whereby we were provided with counsel and technical advice and of course the use of the necessary fuels to put the reactor in being.

Approximately a year ago we had a failure which closed the reactor. Since that time our staff have been devoting their time they had available beyond teaching in redesigning this reactor and working with Babcock & Wilcox in putting back into operation an improved reactor which would be more effective and useful in our research and experimental programs and of course to lend some real aid and laboratory experience for our nuclear engineering students. We have continued in close association with the Atomic Energy Commission and the Oak Ridge group in these matters and endeavors. We are now beginning discussions with Oak Ridge as to our need for financial assistance in the reconstruction and operation of this most useful research and teaching tool.

Up to the present time we have had no direct financial aid from Government sources in behalf of our teaching program or for the construction and operation of the reactor. We have had some research projects with the Office of Ordnance Research and the National Science Foundation which have given some support to our graduate students.

The education program and industries of North Carolina (Burlington Mills) have provided the financial support for our nuclear engineering training program and our reactor construction and operation. We are indeed proud of the leadership position we have taken in the effort to provide well-qualified people in this important field of nuclear engineering. Certainly we would welcome some financial support in this nuclear engineering training program in the School of Engineering at North Carolina State College and which is now operating to train students from foreign countries and the Nation at large as well as from North Carolina. We are indeed in need of financial assistance in the reactivation of our reactor.

Dr. Raymond Murray, acting head of the reactor, and Dr. A. C. Menius, acting head of the physics department, and I would be happy to supply you with other information if you need it, and of course we would welcome the opportunity to talk with you, and others with respect to nuclear engineering education and the operation of research and training reactors such as ours here at North Carolina State College, Raleigh, N. C.

Sincerely,

J. H. LAMPE,
Dean of Engineering.

Representative DURHAM. This committee has been trying to stimulate that program for many years.

The matter of the other suggestion that you have here is somewhat along the line that the high school teachers are not receiving adequate pay to attract them and keep them in their teaching positions. Have you given any thought as to how we might approach that beyond the State salary level or beyond the level that they are being paid today? I think we have got to do it, whether it is by the Federal Goverment or the State government. Somebody has to keep those in their positions, or otherwise, we will not get any results.

General SARNOFF. I agree with your statement, sir. I cannot say that I have given any thought as to how the desired result can be achieved, because that is a little out of my line. I have read about it, I have listened, I have talked, but I am not prepared to suggest a program of how to do it, except that the results seem to me to be vital. The teaching profession, after all, is a profession of the highest dignity, and the highest importance in our Nation. We can't ad-

vance any faster than our young people advance. When you compare the salaries of teachers at all levels, public schools, high schools, colleges, universities, they compare most unfavorably with salaries paid in employments outside schools.

Representative DURHAM. That is certainly true. That has developed in my lifetime. In the old days at Chapel Hill, I remember that a college professor was the best paid man in the State. Now it is the reverse, and he is about the poorest paid in my community. That has reversed itself in the short period of my lifetime.

Somehow, our educational system, being one of freedom of choice—and I hope we will maintain that—we have to get competition on a selective basis. It is now almost a forced basis. I don't think the people of this country realize how serious the problem is. Everybody is talking about it, but some action must be taken somehow. Anybody that can come forth here to solve this complex problem would be doing a wonderful job. I think we will do it once we make up our minds as to what we want.

General SARNOFF. Yes, sir; I think your committee is performing a very vital function. It is before a forum such as this that you can bring people before you who are competent to make specific recommendations as to how to deal with it. It is out of these hearings that I am hoping that an answer might come.

Representative DURHAM. Thank you very much, Mr. Chairman.

Representative PRICE. Mr. Patterson.

Representative PATTERSON. General, I want to commend you for the excellent statement you have presented. I can see that you have put a great deal of thought into your remarks. As I was going through your statement, I noted you ask the question, "Why aren't there more young people in America going on to become scientists, engineers," et cetera.

I have had many occasions to talk to students and actually question them as to why they are not thinking along the lines of becoming an engineer or scientist, and in the majority of the cases, General, I have found that it is a question of financial assistance. I think a scholarship of $500 is great. But it is not quite enough to see a boy through college. In fact, in many cases there are young boys in our grammar schools who, if given a real close aptitude test, you would find are almost geniuses, but they are in the position of not being able to continue their education strictly because of finances.

I would like to ask you this question: Have you ever given any thought to setting up an academy of science similar to our Naval Academy, our West Point, now our new Air Force Academy, and the Coast Guard Academy, that are really subsidized by our Government, and have the boys who go to those schools apply the same way as they do these other institutions, and it would be strictly on merit—100 percent so? It is in my opinion that in that way we eventually would be able to fill this gap in industry and Government. Have you ever given any thought to that?

General SARNOFF. I have not given that any thought. It is an interesting suggestion. Of course, it is a matter of careful balance here. I would hesitate to go so far in my recommendation as to suggest that the Government really finance the education of boys who otherwise may not be able to go to college. That problem has been in existence

ever since we have been a country. Many people are unable to finance themselves through college. But ways are generally found, particularly by those who really want to advance, and who have a desire to become professionals. I think the present situation, of course, goes far beyond that because of our national needs, and the needs for security, and the general economy in a technological age.

I would certainly think that the setting up of an Academy of Science is an aidea that is worth exploring. But you would want to be certain when you took them that when they graduated, particularly if the cost of their education had been paid by the Government, that you had some control or assurance of what they were going to do when they graduated.

Representative PATTERSON. Of course, even at the Naval Academy and West Point and our other military academy, the only guarantee you have is that after a man graduates he stays in the service for a certain number of years. The same requirement could be made to graduates of this academy that we have reference to, where he would go to work for the Government for 2, 3, 4, or 5 years, whatever the requirement might be, in order to satisfy our Government so that we would be getting something for the amount of money invested. That is one way we could stay in close competition with Soviet Russia.

Right now they have a terrifically stepped-up educational program pointed directly at the scientific field, from the information I have received. Over there it would be a little different than what we have here. They are compelled, because there is a threat that if I don't become a good scientist or a very important man in my community, I can go to the coal mines up in Siberia. Whereas, here it is the free will of the individual youth as they have at the Naval Academy, for example.

General SARNOFF. Your idea is new and very interesting. I think it is well worth exploring further.

Representative PRICE. Senator Pastore.

Senator PASTORE. I want to say to you, General, that I was not here when you commenced your statement, but I have been trying to pick up since I have been here, and I am very much impressed with it as the other members of the committee are. I want to congratulate you for it, because I think it is penetrating and provocative, because it is a problem that affects us all. I think sometimes we make a mistake when we try to tie our educational deficiencies with this whole business of atomic energy in order to glamorize it.

Fundamentally, I think there are deficiencies in education far beyond the field of atomic energy. I think atomic energy, and the development of it, both research and otherwise, has sought to accentuate some of our deficiencies.

Talking along the lines of the deprecation, if we must use that word, of the dignity of the teaching profession, I would like to give you a litle story. When I was Governor of my state, I was visited by four male high-school teachers. One of these men was the father of four children. He looked at me and said, "You know, Governor, I don't mind too much if I have to have a spare job in order to support my family, even though I am a teacher, and that spare job of mine is working at the corner gasoline station pumping gasoline. But I think I take a little too much when one of my students drives up with his father's car and says, "Fill it up."

That is exactly what we are falling into. I think myself that essentially much of the trouble in the country today is that we have lowered—not through anything that the teachers themselves have done—through a sense of indifference on the part of the public, the dignity of our teaching profession. I rarely have ever met a teacher who is not looking to getting into private industry where he would be respected as a gentleman and would be paid as one who is supposed to support his family on some level of respectability. I was very much intrigued with the statement that you made on page 3 of your statement where you said:

> Of course, a police state can and does compel its youth to enter a career of its own choosing. It conscripts minds as ruthlessly as it conscripts bodies. That kind of regimentation—

and I join you in echoing that same sentiment—

> is ruled out in this country.

However, while that may be so, I do not think we ought to be lulled to sleep there through a cliché. I think that ought to be a challenge to us to do something about it in our way.

I had some statistics gathered. I am going to get to a question pretty soon but I am laying the predicate for it. Three percent of those students who reach junior high school age ever finish college. Mind, 3 percent of the boys and girls of the United States of America who reach junior high school age ever go to college.

Then I have another figure here that says that last year we graduated 249 men and women who are qualified or could be qualified to teach physics in high school.

I realize that private industry as such has done a marvelous job. As a matter of fact, the only job that has been done I think has been done by private industry. I am very much refreshed to see some of these endowments and gifts that are being made to some of the higher schools of learning, which are very, very refreshing. But don't you think that we ought to broaden out this system of scholarships in America? Don't you think that somehow we ought to more or less guide young men and young women who have special talents in the field of science or medicine or biology or what have you? If the family doesn't have the necessary wherewithal by which they can go to these schools, that something ought to be done so that our best will not fall by the roadside, according to a democratic process?

General SARNOFF. Yes, sir; I feel that any help we can give within our democratic process and without setting up special or privileged classes, we ought to give. I think that there are many ways to do that without actually subsidizing every boy and girl that has ability. I think to begin with that we have got to make a greater effort to encourage those who would go if it was more interesting. For example, in many high schools, and even in colleges the subject of physics and of chemistry and of science is just not made attractive enough to hold the interest of the student. That is one of the things I have tried to point out in my opening statement. One of the advantages that I see at least for the next few years during this period of emergency is that if we can infuse into the schools, particularly the high schools, the experience and the spirit of men and women who have actually accomplished with their own hands and their own minds results in laboratories and factories and offices, it would operate like

a chain reaction. We ought to exhaust all of the efforts in that direction before we adopt a broad program of subsidy or finance.

Furthermore, that subject requires further study and further analysis. As I have tried to recommend here this morning, we ought to have a survey and talk to these young men and young women at the times that they are faced with the decision as to their future. Is it finance, is it lack of interest, is it the greater enticement of industry? I don't think we have enough facts. We have a lot of opinions and a lot of suggestions, but no facts.

Senator PASTORE. I agree with that, General. I will tell you very frankly the educators of this country had a symposium or some kind of conference in Washington, and I have not heard a single word about it in the Congress of the United States. I don't know of any committee that has reviewed that report. We are doing precious little about this whole business. Everybody seems to recognize the problem, but nobody seems to be doing anything about it.

General SARNOFF. You are quite right.

Senator PASTORE. That is the thing that frightens me. Along the lines of not subsidizing education—and I quite agree with you on that—I remember when I was a boy if you really wanted to go to college or you wanted to go to high school—I am one of those who did not have the opportunity to go to college—all you had to do would be to go out and get yourself a job after school. Maybe in your day that was even much more common than it was in my day. In my day I couldn't go to college because my family needed the paycheck. So I regret that I did not have the opportunity. But realizing that the average income of the American family is about $4,000 a year, and it costs about $2,000 a year to send a boy to college, how can we do that and how can that job be done especially according to the curriculum of today where a boy is not expected to get himself a job when he is studying certain subjects.

How can that job be done unless you have some attraction that recognizes these abilities that might go to waste if we don't develop them? I am not talking about socialism, because I am against it, but I realize the problem.

General SARNOFF. I understand that. It is a problem, but it is a problem whose roots go very deep. If you will pardon a personal reference, since you referred to my days and yours, although you are a much younger man than I, I can say this to you. When I was a boy, I had to go to work. I didn't even get a high-school education. But somehow or other, I did have an interest in getting a technical education. I worked in the daytime and I studied engineering at night. That was not regarded in my days as anything unusual. I went to Pratt Institute in Brooklyn, and after a day's work I studied engineering at night, and the help I got as a result of that study, I have often felt was the most valuable help I could have gotten as a boy.

Senator PASTORE. That is my question. Is that a common practice today? That was pretty common in your day and my day, too. I went to night law school. That is the way I became a lawyer myself. I kicked a foot press every day I went to high school. Is that common today? I do not hear of that any more. Our schools do not gear their curriculum that way any more.

General SARNOFF. I do not know whether it is common, but there are still night schools. I know of no reason why boys cannot go to

evening school and improve their education and knowledge. Of course, it is true that technology has moved on considerably since your day and mine. I don't know that a smattering today is sufficient. You have to have a trained man, and he has to be taught the modern things. These night schools are helpful and stimulating, but I don't think they would entirely meet the kind of situation that we face today.

Senator PASTORE. Here is another thing I should like to point out to you—not that it is related to atomic energy, but it covers the whole field of lack of facilities. We have two handicaps to overcome. One is trained men. Without a good faculty no school will ever be good and turn out good graduates. Then you need facilities to accommodate the people who attend the schools and have the proper atmosphere in which to develop.

In my own State there are 20 young men who are attending medical school abroad, and these men are attending medical school abroad because there is no medical school here in the United States to which they can be admitted. When I was Governor of my State, one of the biggest problems I had was in convincing parents that I did not have the authority nor the prestige to get their children into medical schools that they wanted to send them to. They thought if they came up to see Johnny Pastore, he can fix anything. There is only a number they can take, and that is limited. We have I don't know how many thousands of our young men who are continuously being frustrated because they want to become doctors and cannot.

The point I make in this: 19 to 20 boys in my State go to Italy to a medical school. Here we are sending foreign aid money to Italy to prop up their economy. If a country that we are propping up their economy has the facility and has the ability to have medical schools to train American students, why in the world can't we do it here in America? It is enough to make anybody angry. That is one of the things that is bothering me. We just allow this thing to pass on and pass on and pass on, and nobody ever does anything at all about it, outside of stating a few clichés that seem to make everybody happy for the moment. But nothing specific ever happens.

I am very happy that a man of your caliber—and I know of no man who is better qualified to speak to us on this general subject of technicians and scientists, because I think you are one of the leading businessmen in this country and we are very proud of you—and I am happy you came here this morning to address us.

General SARNOFF. Thank you, sir.

Representative PRICE. General Sarnoff, I agree with what the other committee members have said with regard to your statement. I think it is not only a splendid statement, but a challenging statement. You have recommendations in here about which something should be done.

I might mention first your idea about the National Education Reserve, and that possibly it should be set up under an act of Congress.

My first reaction was that it would be very difficult to do. I do not know of any similar organization. Then it came to my mind that we have an analogous situation in the Civil Air Patrol. This would be a sort of Government encouragement to a program. I do not see why it could not be done. Such a plan was never proposed by this committee but it could generate here. So studying your statement more

thoroughly, I see it is a possible way and we should give serious consideration to it.

We are very much interested in the reactor programs for universities. This committee has been interested in it for some time. Mr. Durham has done a lot of work. His State university is one of the two universities in the country that do have a reactor program in operation.

We have been interested in spreading this technology and the opportunity for the training of nuclear scientists more generally. The Atomic Energy Commission has come up with the reactor kit idea. We would have to go a little deeper than that to get a good thorough program going in the universities.

I am just wondering whether or not you thought that private industry itself might begin to endow certain universities with some of the necessary things that they would have to have to get into the reactor program on the same scale as Penn State and North Carolina. Do you think there might be a disposition on the part of private industry to increase the endowments to universities along this line?

General SARNOFF. I think there might well be, particularly among those elements of industry that are concerned with the development of atomic energy. I agree with what Senator Pastore said about atomic energy not being the only element of science. It is hard to separate atomics from electronics. They are twin brothers. When you open up an atom, there are electrons inside the nucleus—lots of them around it. These buildings blocks of the universe—the atom and the electron—presumably came at the same time. One has a relationship to the other. No one can study atomic energy, for example, without studying electronics. No one can study electronics without moving forward into atomic energy. All I am trying to suggest here is a stimulation, some guidance, some direction, some encouragement. I think you will have to leave it to the educators as to the courses, to industry as to what particular things they can assist in. I am sure that the Federal Government at the present time—and a committee such as yours—are in the best position to furnish a background against which progress can be made.

For instance, the National Educational Reserve that I am talking about; it is not in my mind that that should be an operating agency in any sense, any more than the military reserves are an operating agency. But a man who belongs to the military reserve—I happen to be a reservist myself, and as you know, I am Chairman of the National Security Training Commission, which this week is going forward with the National Reserve Week—we do have an organization. We have something to tell people. We have a message to deliver to them. They have some evidence of belonging to something, of discharging their patriotic obligation as a citizen to help maintain the strength of our Nation. In the educational field, we have nothing like that. If we did, I am sure that a great deal would come automatically.

This is not altogether a matter of money or altogether a matter of subsidy. This is a matter of interest. The avoidance of neglect, the very things that have been discussed here, everybody makes a suggestion, it sounds good and nothing happens after that.

Senator PASTORE. If I may rejoin, if the distinguished Congressman will yield, I didn't mean exactly that the problem doesn't belong

ere, because definitely the phase of atomic energy does spell itself nto this overall picture. What I meant to bring out is the fact that his deficiency in education is even broader than that. It gets into the ther scientists apart from atomic energy and electronics.

General SARNOFF. That is true.

Senator PASTORE. It is an overall deficiency in every branch. While e have spotlighted it here because we have glamorized the atom, the act of the matter is that it is just as bad there.

General SARNOFF. You do have at the moment, as I have tried to ay in my paper, an immediate problem. I think the problem must e divided into the short-term and long-term areas. The short-term rea is that unless we increase the supply of trained men—scientists, hysicists, engineers, and so on—we may be beaten by a potential nemy, and we can't afford to be beaten. We can't afford to wait until e solve the overall problem on its widest dimension.

Senator PASTORE. Could you stand another story on that score? We ad a gentleman before our committee not too long ago in executive ession who told us that a group of British scientists were invited to isit Moscow. They brought with them in the group only one man who ould serve as an interpreter to speak Russian. When they got there, ey found out that everyone whom they met on every echelon could peak English beautifully, and that English is a required course for period of 7 years in the science curriculum. That is the competition ou are up against.

General SARNOFF. Yes, sir.

Senator PASTORE. You do not beat that competition with a bunch f cliches. You have to do the job. When we were out there in Geneva, e were impressed with the quality of the Russian scientists. I regret o say this, but the fact of the matter is just as you say, no one nation as a monopoly on brains. Unless you take these talents and develop hem, I am afraid we may lose the contest which may be the difference etween leadership and not.

General SARNOFF. Yes, sir, I agree to that.

Representative PRICE. General, may I say since the Senator from Rhode Island mentioned Geneva, I want to commend the National Broadcasting Co. for sending one of its productions to Geneva for a irsthand presentation to the youth of this country and to the people f this country of the activities that were going on at that time. We eard your production.

The same is true of your production of the American Forum of the Air. I think that is helpful in promoting science. I want to commend ou for that action.

General SARNOFF. Thank you very much, sir.

Representative DURHAM. General, speaking to one other point, you ave had a broad experience in dealing with people in technical ducation lines. What disturbs me is the fact that based percentage-ise—I don't recall the exact figure—there are far less students oing into this field at this stage of our life than there were in 1920. s there some reason for that? Could you point to that? Is it pure aziness? It can't all be teacher shortage and it can't all be one thing. t must be a combination of matters.

General SARNOFF. Relatively I believe you are quite correct. The ercentages are lower today than they have been in the past. I don't hink it is any one reason, sir. It is a combination of reasons. First,

the opportunities for employment in other fields are much wider toda than they were 20 or 30 years ago. Secondly, the disparity in incom as we have discussed here this morning, between the pay that teacher can get at a school and an engineer can get working in a plan Then I think we have just not done enough, all of us, to encourag the young people to do it. The courses have to be made more interes ing, all of the things that we have discussed here.

Representative DURHAM. Of course, in my day I had what I woul call very poor instruction. Mathematics and those subjects, althoug I feel I had poor instruction, were always interesting. Raising family of five children, I have had a little experience from that, to

Speaking on another point on scholarships, I had this experienc recently at the University of North Carolina. A mother wrote m that a boy had finished his third year in nucleonics. His father ha a stroke. I scoured the country to try to get this boy a scholarshi I have had two experiences recently in the same category because mos of the scholarships are allocated when a boy gets there. When a ma gets into his second and third year, particularly in nucleonic engineer ing, and a boy has to drop out from an economic standpoint, it i serious. That is another point. When a man has the capability an gets in that kind of jam—and there must be thousands of them i this country—we ought to have something that we can turn to an give it to him.

General SARNOFF. I agree with you.

Representative DURHAM. As far as I know, there is no such pro gram.

General SARNOFF. I agree with you thoroughly. Such a thing a this reserve organization that we are talking about or education organization, we ought to be able to develop programs and ideas alon that line.

Representative DURHAM. Most of your scholarships are allocated a you know, by a group at the beginning of a year for a full year. Th other thing that disturbs me quite a bit is the fact that qualifie men after they reach the level of master's degree marry and hav 3 or 4 children and don't get their doctor's degree. They have th qualifications. There are hundreds and hundreds of those throughou the country.

General SARNOFF. Industry is doing quite a little in that field. I know in my own company we have men that go through most of th colleges in the country, particularly during the senior years, an select students. We grant scholarships, postgraduate courses. W even take them when they are in the company and send them back t college and pay for it.

Representative DURHAM. Every day and hour in the week in m college in my hometown there are groups from every part of th country talking to every boy that is beyond the level of a sophomor expecting to take him off if he has any scientific training.

Representative PATTERSON. General, I was very interested, being Reserve officer, in your remarks with respect to Reserve officer training Don't you think that this program you have recommended here toda could really be stimulated through our Reserve? It is one thing w really need in order to keep our Reserve officers abreast of the tech nique of new warfare.

General SARNOFF. Mr. Patterson, I have thought that in the educational field where you deal so much with all aspects of our life that ought to be separate from the military institution. You might get some resistance if you had an educational reserve as part of the military reserve. As a Reserve officer, I know, as you do, that there would be no real basis for that objection. Nevertheless, psychologically if you made this part of the military, you would not get as far.

Senator PASTORE. Would it be more or less along the lines of a loan operation as they did during the war emergency where business sent down certain experts for a period of 6 months or a year to work in administrative departments. Would it be along that line, that industry would furnish this reserve, and then it would serve as a pool, and these people would do a certain amount of teaching for a certain period of time, or how would it work?

General SARNOFF. The proposal I have suggested tentatively is that industry continue the person loaned for teaching purposes on its payroll at full pay for a year, and then take him back on his job, and he would retain all his privileges.

Senator PASTORE. And then it would rotate.

General SARNOFF. Yes. One company might give 10, another 15 or 30, but collectively you meet the situation.

Senator PASTORE. We did more or less that sort of thing in strategic materials and allocations during the war period. We had experts in industry to come down and more or less allocate.

General SARNOFF. We have had that. I have been trying to eliminate the onus of the dollar-a-year man. I even eliminate the dollar.

Senator PASTORE. This would be industry in the school. It would not be the Federal Government.

General SARNOFF. That is right. It is more or less along the same line. It is a contribution by industry to the national effort.

Representative PATTERSON. General, I can visualize this kind of situation, as a Reserve officer myself. That is, being called back to active duty, and confronted with NIKE, or as a marine, which I am, being assigned to the Navy aboard ship, and have all of these technical devices that they use in the next war. I would not know where to start because I have had no knowledge of them at all. Our Reserve units are not getting any teaching along those lines at all. How are you going to keep the Reserve officers, which are the backbone of our fighting units, abreast of these vast changes in weapons unless they have had some training in the Reserve unit? I think we should have a group set up to handle the NIKE outfits as Reserves, working in coordination with the Regular Army personnel in the various towns throughout the United States.

General SARNOFF. The exact implementation of the program and the means of doing it—I have not attempted to burden you with details here today. I should hope if the idea and principle appeal to you, that you might then call upon the educators and others to develop a concrete plan. You must have the cooperation of the educators in the country, because the Government itself cannot move in and undertake the job of teaching.

Representative PATTERSON. I think it would stimulate a great deal of interest in our towns and cities throughout the country. For

instance, a boy says, "I am a Reserve officer and I want to expand my technical knowledge a little more. I go down to the Reserve unit on Wednesday or Tuesday night and listen to lectures and so forth given by men who are in the know."

General SARNOFF. That is right. You could have the same thing happen with the National Education Reserve. First, it would have Federal status. Then it would go down to the States and local communities, and the men and women who belong to that could organize their own activities. You would have men lecture to them. You would follow more or less the same principle.

Representative PATTERSON. You can see my point how crippled our Reserve officers are going to be if they are called to active duty and are confronted with these problems of technical know-how of the new weapons when they have never seen them before.

General SARNOFF. You are quite right.

Representative PATTERSON. What are you going to do in a situation like that, General, if we should ever get into conflict?

General SARNOFF. The Army, Navy, and Air Force have their own educational systems. They are teaching their own Reserve officers. I would not deplete industry by sending into the teaching profession any large percentage of their men. Take, for example, a large company that is engaged in technology. If they were able to give 10, 15, or 20 of their men to the teaching profession for a year or so, that would not deplete their staff.

Representative PATTERSON. Getting back to the other question of sending some of our business people into teaching in our various schools, did you ever take into consideration the fact that we might run into some problems as far as meeting the particular educational qualifications are concerned?

General SARNOFF. Yes, sir; there will be many problems of that kind. I think that the obligation upon the educational boards as citizens is as great as it is upon anyone else. I think they have to come across and help solve those problems. The local governments likewise might have to modify some of their requirements to meet this temporary situation. I never would have recommended anything like this if I did not feel that there was not an immediate emergency upon us.

Representative PATTERSON. I think we are all in agreement that there is definitely an emergency and we are confronted with a terrific problem.

Representative PRICE. General, I am just wondering what the situation is on your existing communications system in the various television and radio networks. Are there any public service programs that now attempt to glamorize the scientific and engineering professions?

General SARNOFF. Yes, sir; there are a number of programs of that sort. I do not know that they are specifically designed to glamorize any individual profession. But there are a lot of programs dealing with science, certainly with atomic energy. I know in the National Broadcasting Co., with which I happen to be associated, we have gone to great lengths recently in getting up programs which we call documentaries, to explain how atomic energy works and what it does and how it does it. We had experts in the field participate. It was quite an exciting program and received a most favorable reaction.

I think other networks and other stations are also doing such things. I can't say there is any specific or concentrated effort to glamorize the teaching profession. There has not been any program along that line.

Representative PRICE. Westinghouse had a program. They have an award system whereby they go into the high schools and make some sort of national award each year to high school students. Could not some sort of program be devised on a nationwide basis through the different networks that there would be a national award for the best judged experiment of high school students in the field of chemistry or physics during the year? In other words, a sort of Oscar for the high school student who would come up with some good idea.

General SARNOFF. Yes, sir; there could be. I think it is only fair to say that in general up to the present the efforts of industry have been more directed to the colleges and universities than they have to the high schools. I don't think we have done very much in the high school area. I am hoping when this background which I am recommending is built, that against that background many things of the sort you are suggesting could take place.

At the present time we have not got any Federal agency that is itself leading in that direction. I think the Federal Government must give the original stimulus to the plan we are discussing here.

Representative PRICE. Are there any further questions? If not, thank you very much, General Sarnoff, for your cooperation. The committee deeply appreciates it.

General SARNOFF. Thank you.

Representative PRICE. The next witness is Dr. A. W. Davison, chairman, engineering manpower commission of the Engineers Joint Council.

STATEMENT OF DR. A. W. DAVISON, CHAIRMAN, ACCOMPANIED BY WILLIAM T. CAVANAUGH, EXECUTIVE SECRETARY, ENGINEERING MANPOWER COMMISSION, ENGINEERS JOINT COUNCIL

Dr. DAVISON. Mr. Chairman and members of the subcommittee, I am here today as chairman of the engineering manpower commission of Engineers Joint Council speaking for the 11 member organizations of EJC which have in turn over 210,000 individual engineer members. Needless to say, we are glad to have this opportunity to discuss this problem with you.

I am accompanied by Mr. William T. Cavanaugh, executive secretary of the engineering manpower commission.

For over 20 years I was head of the chemical engineering department of Rensselaer Polytechnic Institute, and for more than 10 years prior to my retirement, I was director of research for the Corning Fiber Corp. Since my retirement I am a consultant of that company. My whole life has been spent in the interest of engineering and technical manpower, both in education and its usefulness to the Nation.

Since 1951, the major goals of the engineering manpower commission, acting on behalf of the principal engineering organizations of the country, have been three: To indicate to our country the growing importance of engineering to our economic development and national security; to promote the most effective utilization of engineers; and

to insure the continuing flow of qualified students into our engineering schools.

The basic motive of such activity is, of course, to fulfill the obligation of a professional group to anticipate and explain the probable effects of new technological developments on the structure and functions of our society. One of the most notable developments in technology which had taken place gradually until 1940, and thereafter with an almost revolutionary impact, has been the tremendous growth in technical activity and the consequent growing importance of engineers and scientists and the technicians of these professions. The fact of atomic development, potent as it is, is only one of several recent reasons for the accelerated interest in technologists. As a matter of fact, the impact of nuclear needs is apparently only beginning.

We realize, gentlemen, that the genesis of your interest in the problem of technical manpower is your great responsibility for the construction and maintenance of an atmosphere in our country in which the great promise of atomic application can be readily achieved. We join you in this sanguine concern. In a unique way, perhaps, we can appreciate the stakes involved. You will recognize, however, that the technologists for nuclear requirements now and in the future must come from the same group as will be expected to fill the overall technological needs of our country. It is, therefore, pertinent for a moment to discuss the present situation of availability and need and the probability for the immediate future.

Representative PRICE. May I say here that I am glad you are touching on the overall picture. While we are primarily interested in nuclear science, the atomic energy program or no other technical program could exist without the overall picture being included.

Dr. DAVISON. They are all intimately associated, sir.

From the standpoint of defense of this Nation, atomic energy, electronics, aerodynamics, the generation and distribution of power, communications, all military offensive matters and all civil defensive matters, require technology of the highest character.

Whenever the subject of need for engineers is discussed, it is essential to provide a framework of overall quantities and recent trends. There are employed now in the United States about 650,000 persons who may be classified as engineers. This is just about 100 percent more than were employed in engineering in 1940.

Incidentally, it is pertinent to note that we have since 1946 absorbed into our economy over 260,000 bachelor graduates of our engineering curricula. About 415,000 engineers are currently employed by private industry. Of these, about 130,000 are employed in research and development activities which have, incidentally, increased overall 1,000 percent since 1941. Approximately 120,000 engineers are involved in some kind of Government activity, State, local, Federal and military. It may be pertinent to note that about 13,000 additions to the profession are needed each year just to replace those who leave for reasons of retirement and what might be called natural causes, such as death.

Each year since 1951 the Engineers Joint Council has made a study of demand for engineering curriculum graduates in industry, education and Government. These samplings have consistently indicated that the overall need for engineering graduates was substantially

greater than the size of the graduating classes. This was the situation in 1951 when about 38,000 degrees were awarded, in 1952 with 27,000 graduates, in 1953 with 22,000 graduates, in 1954 with 21,000 graduates, and in 1955. The number for 1956 has not yet been determinend for obvious reasons.

The results of this year's survey have not as yet been fully appraised but it is possible to provide some indicative values. We have had replies from about 415 industrial and governmental organizations which employ about 135,000 engineers. The firm recruiting goals of these organizations, if filled, would require about half of the entire 1955-56 graduating class in engineering. That is but a small sample.

Within these considerations it is not difficult to understand what might be called some peripheral effects of this 6-year period of manpower deficiency. Government organizations and institutions of higher learning are, for different reasons, unlike industrial organizations, unable to react promptly to the realities of the market place for technical manpower. It is to be expected, therefore, that the discernible results of continuing stress would manifest themselves sooner in these organizations than elsewhere. That is the case. It is very significant, yes, ominous, that for several years now many of the most important Government employers of technical personnel and many institutions of engineering education have shown annual net losses in their struggle to maintain technical staffs reasonably adequate to their missions.

For example, the Corps of Engineers of the Department of the Army, the largest employer of engineers in a civilian capacity in the Federal Government, has, for several years, been unable to recruit a sufficient number of engineering graduates to meet its requirements. Meanwhile, their losses of engineers to other employments are reported to be constantly increasing to an extent constituting cause for concern. This situation can be duplicated in many Government departments and agencies charged with vital national security programs.

As far as engineering education is concerned, Dean Eric Walker of Penn State University recently stated:

> We would have to expand in all directions—facilities and manpower—if we were going to take in any more students and at the bottom of all this is money. Costs are going up very rapidly just because the cost of living in general is going up. Engineers are getting more expensive, engineering equipment is getting more expensive, buildings are getting more expensive. Unless we have very large appropriations for expansion I fear we will not be able to take in any larger freshman classes.

Many other specific examples could be cited but there seems little point in giving further emphasis to the obvious. All of these facts, however, suggest the conclusion that presuming the continuation of the traditional patterns of utilization of technical personnel, there is probably no merely numerical solution in the years immediately ahead to the problems raised by the dearth of competent technologists. This conclusion, which may seem startling, is, as a matter of fact, also suggested by the consideration of an historic fact in relation to some basic knowledge about our human resources potential.

The historical fact is that ever since technology began to affect fundamentally the fabric of our economic system, the ratio of persons with high technical training to all other productively employed persons has been increasing. It is common knowledge now that while, for

example, in 1900, this ratio was about 1 such person to 250 workers, it is now about 1 engineer or scientist to every 60 workers. In certain industrial activities the ratio is even greater.

Representative PRICE. In the figure you quoted earlier as to the number of engineering graduates, you also included the scientific and technichal manpower?

Dr. DAVISON. That was just engineers, sir. With respect to the scientists, it is a different story, although similar. These are engineering graduates.

Representative PATTERSON. At that point, to go one step further with the chairman's question, I note that the number of engineers have diminished from 1951 to 1955 from 38,000 to 27,000 to 22,000 to 21,000. You haven't the figures for this year. It is going to be lower in your estimation?

Mr. CAVANAUGH. We are coming out of that. We are starting a long upward climb, which is the result of two things. First of all, overall college population has begun an overall climb. This is inevitably going to produce more college students in all curricula. In addition to that, we have had about a 4-percent increase in 4 years in the percentage of engineering freshmen as a percentage of all college freshmen. This is the result of the work of the professional engineering societies which was begun in 1951.

Representative PATTERSON. The peak was 38,000. Will you see that this year?

Mr. CAVANAUGH. No, sir. In recent years the peak was in 1950 when we hit almost 50,000. This will probably not be reached within two decades.

Representative PRICE. While you said these are not the scientists, the figures are so similar that we must have been talking almost strictly of engineers before rather than scientific problems.

Mr. CAVANAUGH. The scientific graduations are somewhat smaller, considering that scientists normally have to take some graduate work. Engineers normally complete their formal education in 4 years.

Representative DURHAM. Did you base your 4 percent increase on the number of men in the colleges or the number of graduates?

Mr. CAVANAUGH. No, sir; I was discussing freshmen enrolled in engineering. In 1951, 6.6 percent of all college freshmen were engineering freshmen. Then began a climb which reached in 1954, 10.6 percent.

Representative DURHAM. What do you expect to have graduating in 1960 on your percentagewise figures?

Mr. CAVANAUGH. We ought to be up in the vicinity, just on the projection of college graduations, of 38 or 40 thousand graduates a year.

Representative DURHAM. That would be the figure that was in 1951?

Mr. CAVANAUGH. Yes, sir.

Representative PRICE. You are going to relate that to demand, are you not? While you are going to be up in the number of graduates, will that take care of your shortage?

Mr. CAVANAUGH. This is the point that is discussed in the next couple of paragraphs.

Representative PRICE. Go ahead, then.

Representative PATTERSON. Just one more question. How does that tie in with the statement made by Dean Walker of Penn State? You

say it is going up this year, but he makes the statement that the expenses are going to be greater for engineering and the facilities are going to be smaller.

Mr. CAVANAUGH. This is one of the problems that has been overlooked in this whole picture, I am afraid. Very few people realize that already overall college enrollments are greater than they ever were during the so-called GI bulge. In engineering education, we are only about 26,000 students below what it was at the highest point during the GI bulge in 1946. So we have arrived again at a higher education problem of equivalence to that which we had during the GI situation when there were many indirect economic aids to the institutions of higher education emanating from the Government. These no longer exist. So we have right now a very, very serious problem of staffing and equipping engineering schools where normally engineering education is a very expensive type of education comparatively. So right now there is this problem.

Representative PATTERSON. From that statement, then, the future is going to be very severe as far as handling these students is concerned because of the increase.

Mr. CAVANAUGH. I saw it put this way the other day. Our engineering schools already are breathing hard, and they are only starting up the hill of enrollments.

Representative DURHAM. What do you attribute that fall to principally? It was not economic, was it?

Mr. CAVANAUGH. There were two principal factors. The one that is normally cited first is the fewer number of people as a result of the lower birth rates of the 1930's. This accounts for the numerical dropoff in enrollments, but it does not account for the ratio decline. This is indicative that something happened in the pattern of motivation for these people. When the percentage of engineering freshmen to all other college freshmen fell in a matter of 7 years from 12 to 6.6.

Representative DURHAM. You had about the same engineering schools and faculty as you have today. To put it differently, how do you arrive at the conclusion for the cause? We are trying to find out where this cycle comes in and hits us below the belt. It is a recurring thing in the educational field. It has been going on for years.

Mr. CAVANAUGH. This is a function of the birth rate that took place 17 or 18 years previously.

Representative DURHAM. Do you think the birth rate has more to do with it than anything else?

Mr. CAVANAUGH. This is one of the cases where the most obvious explanation can be misleading. As far as absolute numbers are concerned, it is true that there were fewer people available at the educational age in the early 1950's than there are now or ever will be again in the whole future of our educational institution. So there were fewer people numerically in all curricula.

In addition to that in engineering and science, we had a proportional dropoff. In other words, not only numbers went down, but the number of people in engineering and science compared to the number of people in other curricula also went down. You have to explain this proportionate decrease. This is not a function of merely the number of people. This is a function of the whole fabric of motivation of young people.

Representative PRICE. You may proceed.

Dr. DAVISON. Every indicative measure that we can apply here suggests that this development will try to continue, quite possibly at an accelerated rate. But it must inevitably level for the very simple reason that we will run into the limits of our people to profit from any kind of professional training. We may already be closer to this condition of equilibrium than we realize. Indeed, we present as startling the fact that about 40 percent of our college qualified youngsters do not go to college. I submit that the really startling fact in the situation is that already about 60 percent do go.

Now it must be added, of course, that in a dynamic economy such as ours, this trend of technical employment will undoubtedly be subject to momentary checks, but the long trend line is there, clear for all to read.

It is interesting to note that in Great Britain, Canada, West Germany, other countries in which technology has been recognized as a powerful economic factor, there is great concern at the very highest levels about the availability of technical personnel. You already know of the pressures the Russians are applying to achieve a status in this regard similar to our own.

The development of engineers and scientists is mostly an educational process. It is most appropriate, therefore, that much of your interest is in this educational process and that so many of those who have been here before me have discussed educational needs. We have no intention here of going again over already well explored ground except to emphasize the present and long-range need for the availability of more and better science and mathematics teaching in all levels of our educational system. Steps must also be taken, of course, to insure that our institutions of higher education are able to preserve high standards during a period of steadily growing enrollments.

However, the same root from which education draws much of its great value and strength is, in terms of its relation to the present problem, also a source of great weakness. It takes a long time to educate an engineer or scientist or for that matter any competent professional person. What we can call education lead time may be the single most important fact for your immediate consideration.

Here, gentlemen, is a sobering thought. If we could all agree today on what needs to be done educationally not only in engineering and science but in the other fields important to our national future, and if we could proceed to accomplish the initiation of programs tomorrow, it would still take at least 5 years and more, probably 8 years, to achieve any important results. Only this year, for example, will we begin to benefit from Engineers Joint Council's efforts begun in 1951 to bring engineering enrollments back into more rational balance, a balance from which they had fallen.

It is unfortunately clear, however, that as atomic energy and indeed technology, more broadly speaking, is important to our national security, including its burgeoning aspects of economic competition, the next 5 years will be the crucial ones. We have, in short, to plan on winning the contest with the men already on the field and in the dugout, the students already in our engineering and scientific curricula.

It is most important, therefore, that we consider how well we are doing in what we can call for want of a better term the utilization of

engineering and scientific personnel. Actually the problem is more than just utilization because it involves not only what engineers do, but the employment atmosphere, rewards, etc. I think it fair to state that in general 5 years ago almost all areas of engineering employment were weak in this respect at least to some extent. There was, therefore, reason for the great emphasis on utilization contained in the approach to this problem by the Engineers Joint Council. I have here a recent report on this by the council. Perhaps you would want to include it in the record. It is concerned with the professional standards and employment conditions within the engineering profession.

(The report referred to follows:)

PROFESSIONAL STANDARDS OF EMPLOYMENT CONDITIONS

Task committee review, February 22, 1956

FOREWORD

Unlike the members of most learned professions, the engineers usually is an employee rather than a private practitioner. Surveys indicate that about 80 percent of professional engineers are in the employee classification, and this situation sometimes creates special problems which are not inherent in the other professions. One such problem is how specifically to create and maintain an employment atmosphere consistent with high professional standards.

Certain conditions of employment have had a profound influence on engineers and, among other factors, have caused a number of professional employee groups to turn to collective bargaining. There is a need, therefore, for the engineering profession to state clearly the employment conditions that engineers expect as professional men. Employers should aline their policies with respect to the engagement of professional engineering personnel to meet these expectations. Mutual understanding between employers of engineers and the engineering profession is essential to the establishment of an environment which will encourage the individual engineer to achieve full professional stature.

A special committee of Engineers Joint Council was charged with a study of this employment problem and the preparation for Engineers Joint Council of "a means of education of and vertical communication to the membership of the constituent societies (including students) concerning conditions surrounding unionization of professional personnel."

Another assignment of the special committee was the preparation of information for employers of engineers concerning employment practices, educational opportunities, and general measures for professional development that influence the attitudes of engineers toward a true professional outlook.

REPORT OF ENGINEERS JOINT COUNCIL—PROFESSIONAL STANDARDS AND EMPLOYMENT CONDITIONS

The Engineers Joint Council has prepared the following report with a view to analyzing the problems of current employment conditions as they relate to the individual engineer. The major topics studied and covered in this report are as follows.

1. The present situation.
2. The causes of this condition.
3. Summary of historical background.
4. Statement of the problem and suggested solutions.
5. Engineering—a profession.
6. Employee's responsibilities in the engineering profession.
7. Management responsibilities in the engineering profession.
8. Engineering societies' responsibilities in the engineering profession.
9. Engineering education's responsibilities in the engineering profession.
10. Conclusions and recommendations.

1. THE PRESENT SITUATION

The expansion of engineering from its beginning in military and civil engineering a century ago to a multiplicity of disciplines today has created a host of problems. Of major concern to the engineer is his relationship as a professional man with his employer. This relationship is influenced largely by employment conditions including salaries, training programs, security policies, levels of responsibility, job classifications, and identification with management.

Because the needs, responsibilities, and contributions of professional employees have not been recognized adequately in some instances there has been a movement toward the unionization of engineering personnel. This has had an adverse effect on the professional concepts of many engineers, for a professioal man must rely first on his own personal competence and integrity for recognition. In addition, confidential relationships which should exist between employers and professional engineers have been jeopardized.

The fact that there has been a trend toward collective bargaining by engineers, in spite of widespread reluctance to participate in such action, demonstrates the existence of unsatisfactory conditions. The engineering profession and management have a great stake in the solution of the problem and the latter must accept its share of the responsibility for alleviating unfavorable employment conditions.

2. THE CAUSES OF THIS CONDITION

The reasons which have fostered collective bargaining among engineers have been studied and may be grouped as follows:

A. Professional treatment

(*a*) A feeling among engineers that they were not identified with management, whether they were employees in industry, private engineering firms, or public service.

(*b*) Inadequate channels of communication between top management and nonsupervisory engineers.

(*c*) Inadequate recognition of the engineer as a professional employee.

(*d*) Assignment of engineers to subprofessional work.

(*e*) Undue retention of engineers in specialized and narrowly compartmentalized assignments.

(*f*) Lack of appropriate means for resolving individual problems.

B. Personal treatment

(*a*) Inadequate recognition and treatment of the engineer as an individual.

(*b*) Lack of broad position classifications and appropriate titles by which the engineer could measure his progress.

(*c*) Inadequate or nonexistent plans for training and job rotation.

(*d*) Inadequate understanding of promotional policies and belief that progress and promotions were not commensurate with ability and performance.

(*e*) Feeling of insecurity of employment.

(*f*) Management's human relations knowledge and skills have not kept pace with the expanded utilization of engineers.

C. Financial treatment

(*a*) Engineering salaries not commensurate with fundamental contribution.

(*b*) Too small a differential between the pay of engineers and members of the skilled trades.

(*c*) Salaries of experienced engineers not sufficiently increased, in comparison with present starting salaries.

(*d*) Wide variation in salaries paid to engineers doing comparable work in different organizations.

(*e*) Dissatisfaction with merit review systems and inadequate understanding of salary administration.

Faced with these conditions, some engineers have resorted to unionization in the belief that corrective action could be effected only by pressures on management through collective bargaining. Even though they may have realized that professionalism requires freedom of action, these engineers appear to have been willing to submerge this principle in their attempt to get more pay and better working conditions through union activity.

8. SUMMARY OF HISTORICAL BACKGROUND

The accelerated development of mass-production techniques in this century stimulated a rapid rise in labor union activities. Labor and management faced common problems of increasing complexity. In 1935 the United States Congress enacted the National Labor Relations Act, better known as the Wagner Act, which guaranteed to employees the right to organize and to bargain collectively and protected labor unions against specified unfair labor practices on the part of management. At that time there was little realization on the part of the professions of the potential impact of the Wagner Act on professional employees. However, the established labor unions soon took advantage of the situation and it was not long until many professional employees found themselves included, against their individual desires, in heterogeneous bargaining groups.

Legally, it was possible to form bargaining groups composed solely of professional employees. Practically, it was difficult to do so. Wherever a heterogeneous bargaining unit existed, it was next to impossible for professional employees to segregate themselves since the Wagner Act made no distinction between them and nonprofessional workers.

Some engineering societies, particularly the American Society of Civil Engineers, undertook to chart a course of action designed to assist professional employees against inclusion in heterogeneous groups. At first, the effort met with but minor success. Later, Engineers Joint Council determined to present its views to Congress with the hope that the Wagner Act might be amended to provide recognition of the status of professional employees and to enable them to act effectively on their own behalf. Pertinent clauses were included in the Labor Management Act enacted by the Congress in 1947—better known as the Taft-Hartley Act.

Of interest to the engineering profession, this law specifically provides under section 9 (b):

"The Board shall decide in each case whether, in order to assure to employees the fullest freedom in exercising the rights guaranteed by this Act, the unit appropriate for the purposes of collective bargaining shall be the employer unit, craft unit, plant unit, or subdivision thereof: *Provided*, That the Board shall not (1) decide that any unit is appropriate for such purposes if such unit includes both professional employees and employees who are not professional employees unless a majority of such professional employees vote for inclusion in such unt * * *"

The term "professional employee" as included in the Act reads—

"(a) any employee engaged in work (i) predominantly intellectual and varied in character as opposed to routine mental, manual, mechanical, or physical work; (ii) involving the consistent exercise of discretion and judgment in its performance; (iii) of such a character that the output produced or the result accomplished cannot be standardized in relation to a given period of time; (iv) requiring knowledge of an advanced type in a field of science or learning customarily acquired by a prolonged course of specialized intellectual instruction and study in an institution of higher learning or a hospital, as distinguished from a general academic education or from an apprenticeship or from training in the performance of routine mental, manual, or physical processes; or, (b) any employee who has (i) completed the courses of specialized intellectual instruction and study described in clause (iv) of paragraph (a), and (ii) is performing related work under the supervision of a professional person to qualify himself to become a professional employee as defined in paragraph (a)."

Under the Taft-Hartley Act a group of professional employees in any place of employment may decide by majority vote of their own numbers whether they want to form a unit of their own for collective bargaining purposes, to join with some other bargaining group, or to refrain from collective bargaining entirely.

It was hoped that the amended act would provide a satisfactory solution to the inclusion of engineers in heterogeneous unions. Professional employees could disassociate themselves from heterogeneous groups. It was not expected that employees of professional status ever would desire anything like a nationwide bargaining union. It was hoped that labor unions would respect the statutory rights of professional employees.

Those hopes today lack much of full realization.

A number of bargaining groups of professional employees have come into existence. Some appear to have functioned constructively; the same hardly can be said of others. Already there is a nationwide union, self-designated as an engineering union, which aspires to power. Although some professional employees

have been able to disassociate themselves from heterogeneous groups, craft unions, particularly in the construction industry, are forcing more and more engineers into their ranks by bringing economic pressure upon employees, thus avoiding the election machinery of the Taft-Hartley Act. Clearly, many members of the engineering profession and employers of engineers are not doing enough to ensure enforcement of the letter and the spirit of the law.

The recent merging of the American Federation of Labor (AFL) and the Congress of Industrial Organizations (CIO) brings into being a large and powerful labor organization among whose objectives are increased efforts toward unionization of office employees and technical personnel. That effort will have direct impact on professional engineers.

To obtain reliable statistics regarding the current status and thinking of a cross-section of the engineering profession. 4 constituent members of EJC, namely ASCE, ASME, AIEE, and SNAME, polled 117, 917 of their members on specific questions concerning collective bargaining. Of those polled 66,938, or 57 percent, responded.

Returns showed that 48,082, or 72 percent, of the 66,938 respondents opposed collective bargaining for professional engineers, and that 44,168, or 66 percent, felt that collective bargaining is incompatible with professional status.

Further, the 66,938 responses showed that less than 4 percent were actually members of established collective bargaining groups; 27 percent reported as not being opposed to collective bargaining; 20 percent reported that they believed collective bargaining would be advantageous to them; and finally, less than 1 percent of the membership of three member societies (the fourth did not ask the question), would prefer to be represented by a craft labor union.

These results present a challenge to the engineering profession and to engineering management. The thinking of the remaining 43 percent of the 117,917 members polled, who did not respond to the questionnaire, is still unknown, but, assuming that the sample was representative, there would then be 30,300 members who are not opposed to collective bargaining for professional engineers.

These results emphasize the situation confronting the profession in spite of the protective clauses in the Taft-Hartley Act.

4. STATEMENT OF THE PROBLEM AND SUGGESTED SOLUTIONS

A summary of the above might lead to two basic reasons for the present situation:

1. Engineers have not always realized and understood the professional characteristics of their roles.
2. Management has not always realized and accepted its obligations to engineers.

If these are the causes, the problem then may be stated as how to get the engineer to appreciate the professional characteristics of his position and how to get management to realize and accept its obligations to its engineers.

Immediately certain solutions present themselves, and these may be listed under five main headings:

1. Point out to the engineer and reemphasize to him that engineering is a profession and that he therefore has certain definite responsibilities.
2. Point out to management, through all feasible ways, that it has responsibilities to the engineering profession.
3. Point out to professional societies the part which they should play in the advancement of their profession.
4. Point out to engineering educators their responsibilities for developing professional concepts in their students.
5. Point out to society the contribution of the engineer to its general welfare.

The purpose of the rest of this report will be to bring to the attention of all concerned their respective responsibilities. It is hoped that sufficient distribution and publicity will be given to it to stimulate a realization on the part of the public that engineering is a profession with high ideals and one that has made preeminent contributions to our modern civilization and high standard of living.

5. ENGINEERING—A PROFESSION

Engineering is the art and science by which the properties of matter and energy are made useful to man in structures, machines, and products. Accomplishment of these ends requires not only scientific training, but also creative imagination, judgment, and an appreciation of the economics involved. The work of

the engineer is predominantly intellectual and varied. The dictionary defines engineering as a mental activity rather than a manual skill. The engineer must exercise discretion and judgment, he must wish to serve, and his relationship with management must be one of confidence; in fact he is part of management. The engineer is charged with the protection of the public health and the public safety. The builder of a bridge, an airplane, a water supply, a dynamo, a kitchen range, an automobile, or a chemical plant must be concerned with its safe operation. Responsibility rests upon his shoulders; if he does not accept that responsibility, he is not professional.

Professions require knowledge and skills on a high plane and all require that the practitioner work in a relation of confidence. In the ministry, medicine, and law this relationship is usually on an intimate personal basis, but in engineering it usually is more general and, indeed, involves obligation to the public at large as well as to the employer or client. The engineer's code of ethics requires that "he will have due regard for the safety of life and health of the public and employees who may be affected by the work for which he is responsible" and that "he will act in professional matters for each client or employer as a faithful agent or trustee."

Since clients and employers usually do not have the technical knowledge necessary to judge technical work, the engineer is bound to place their protection above his personal convenience or his immediate personal gain. A fundamental principle of professional responsibility is trusteeship. This is also a fundamental principle of management. To the employed engineer this means that the professional attitude involves a "management-oriented" point of view.

Engineering operations today are varied and extensive. Men at all levels of training and competence are required to carry out vast engineering enterprises. The work of the draftsman, the layout man, the toolmaker, the plant operator is indispensable, but does not require the imagination, the educational background, nor the judgment of the engineer who conceives and executes the broader aspects of the projects.

The work of a truly professional engineer is so far from a routine, established pattern that only he can provide the initiative, the discretion, and judgment to achieve the successful accomplishment of his particular tasks. Because he alone knows with what comprehension, ability, and likelihood of success he approaches his assignment, the professional must accept individual responsibility or else advise his client or employer that other help is needed.

Professional attitude involves the following five basic concepts:

(1) A social consciousness, a desire to contribute to rather that simply to benefit from civilization; a resolve to place the public welfare above other considerations.

(2) The acquisition of special skills on a high intellectual plane, generally evaluated by means of self-imposed standards of excellence.

(3) A sense of trusteeship—personal responsibility to protect the client's or employer's interest.

(4) Individual initiative and acceptance of individual responsibility, both of the highest order.

(5) A right to expect and to receive adequate financial recognition.

Prestige, however, is something that must be won. It cannot be bought or automatically accorded through affiliation with an organization. It is something that one can command but never demand. In the final analysis, an engineer achieves professional standing only to the extent that he accepts his responsibility to himself, to his client or employer, and to society.

Attainment of a degree in engineering from an institution of recognized standing implies that the graduate has mastered a certain curriculum and that he has the ability to understand, to assimilate, and to apply the knowledge that qualifies him to become a member of the engineering profession.

Although social consciousness is not necessarily a corollary to superior mental competence, most people who are endowed with such competence do have a sense of responsibility to the social order of which they are a part. They have learned to look on life as an opportunity to contribute to the civilization that fostered them and thus to better the lot of those who follow. To the engineer who feels that life provides opportunity for constructive contribution to society, collective bargaining with its attendant potentiality for creating conflicting obligations is not acceptable.

6. EMPLOYEE'S RESPONSIBILITY IN THE ENGINEERING PROFESSION

"An an engineer, I will participate in none but honest enterprise. To him that has engaged my services, as employer or client, I will give the utmost of performance and fidelity." (Faith of the Engineer.)

The engineering employee is bound by the same ethical and moral principles that apply to a member of any other learned profession. The responsibilities of an engineering employee are many. He is obliged to perform the professional assignments entrusted to him to the best of his knowledge and ability. He should give needed professional counsel in his special field and render loyal service. He should respect the economic problems of his employer. He should be thorough, expeditious, original, and accurate in the execution of his duties and assignments. He should have a rational attitude toward his work and fulfill each task with a minimum of supervision. At all times he should strive to improve the quality and increase the quantity of his output.

Education is important to the engineer and he should foster its continuance for those who are subordinate to him. He should strive to recognize and to utilize the diverse capacities of all fellow employees. He should strive for good planning and clear, concise reports. He should be friendly and maintain good appearance. He should develop the ability to be a good listener as well as the ability to express his thoughts effectively.

It is axiomatic that just as management has responsibility to employees, so do employees have responsibilities to management. The engineer employee should realize that he is not just another hired hand. He should know that to achieve full professional stature he must develop himself to rise above the technician or engineering-assistant. He must have genuine desire to expand his capacity, to extend his knowledge, and to improve his proficiency.

Any employee who is unwilling to assume responsibilities beyond those accompanying his present job has little right to be critical about lack of advancement. If he feels that he is not getting earned recognition, it well may be that critical self-appraisal is in order. One cannot just wish himself up the ladder or depend on someone else to push or pull him along the way to success. The fact that a man has acquired a bachelor's degree in engineering does not, of itself, entitle him to any lasting professional recognition. It remains for each individual to prove by his own ability, integrity, and conscientious application to duty that he deserves recognition.

7. MANAGEMENT'S RESPONSIBILITIES IN THE ENGINEERING PROFESSION

Surveys show that more than 40 percent of management were trained as engineers. It seems illogical, therefore, that often there is inadequate communication between management and engineers with consequent lack of understanding on the part of management of the reasons for dissatisfaction among professional employees.

Management must recognize the inherent professional character of engineering work. It should be a policy of management to use its professional employees to the maximum of their capabilities. Except during the training period the engineer should not be assigned to tasks which do not require his technical training and he should be accorded individual and professional status commensurate with the quality of his contribution.

There must be opportunity for a continuation of education. It is important that professional employees be given opportunities to participate in activities of scientific and technical societies. It is important that they receive credit for their contributions to the advancement of technical knowledge or the profession as a whole.

There must be adequate communication between management and the professional employee. There should be organized orientation and training programs for new employees. Engineers need to understand the basic policies of their employer. They need to know their responsibilities and their opportunities for advancement. Adequate management-employee communications require a day-to-day relationship supplemented by periodic performance reviews, and other appropriate techniques.

Salaries must be established which will recognize the contribution of the professional employees as related to that of other groups. Salary differentials between various levels of technical experience have been substantially narrowed during recent years. Engineers who, after a period of satisfactory employment, find their salaries are only slightly higher than those of the recent graduate and

possibly lower than those of a skilled craftsman are not working in a favorable atmosphere.

Management must minimize the fear of job insecurity by adopting feasible means for stabilizing the employment of professional personnel and suitable termination policies. Since many engineers become managers, there is a need to insure that they are employed and developed in an atmosphere which will fit them for their future responsibilities. Executive talents must be developed by experience and training in those phases which lead to managerial responsibilities.

8. ENGINEERING SOCIETIES' RESPONSIBILITIES IN THE ENGINEERING PROFESSION

The engineering societies must take the lead in the advancement of the profession. Among the basic responsibilities of the engineering societies are the establishment of standards of ethical conduct, rigid requirements for admission to membership, accreditation of educational institutions which grant engineering degrees, and awards and prizes in recognition of worthy contributions to the advancement of the profession.

The national engineering societies have an additional responsibility to foster a healthy professional climate for employed engineers. Their governing boards and their individual members should unite in exerting their best efforts toward solving the problem. These responsibilities are so challenging and so vital to the current problem that they must be considered as obligations.

Current efforts of national committees to encourage professional development of engineering society members and to promote recognition by the public of the professional character of the engineers' work should be expanded. An objective evaluation of the problem should be continued, followed by specific recommendations for the good of the profession. Engineering societies should adopt official statements for membership information with respect to collective bargaining to the extent permitted by their charters and constitutions. They should acquaint their memberships with those provisions of the Taft-Hartley Act which have a special significance to professional engineers. Constructive programs for encouraging professional consciousness on the part of engineers both before and after graduation should be sponsored. Therefore, the engineering societies and Engineers Joint Council should inform management as to the standards that will contribute to full professional achievement.

The engineering societies should provide guidance and assistance to educational institutions confronted with any problem which is detrimental to the achievement of full professional training of students.

9. ENGINEERING EDUCATION'S RESPONSIBILITIES IN THE ENGINEERING PROFESSION

Engineering colleges have a primary responsibility for developing professional concepts in engineering students. Professional concepts should be developed through their application to the solution of engineering problems in the technical courses, lectures, association with students, and by good example.

Opportunities for engineering educators to become better acquainted with the total environment in which engineers work should be expanded through temporary employment in nonacademic fields and the utilization of employers with "professional vision" in the classrooms and student seminars. Such activities enable students to appraise their status more realistically upon graduation.

10. CONCLUSIONS AND RECOMMENDATIONS

There are obligations and responsibilities resting on both employer and employee. Each, of course, has responsibility to advance his own welfare. Beyond that, and yet a part of it, each has responsibility to the other and to society. Grave responsibilities for inculcating and developing professional consciousness in young members of the profession rest upon the educational institutions and professional societies. Various phases of such responsibilities have been tressed in the several section of this report.

Without a sound technical foundation no man can become a competent engineer. But more than technical competence is demanded of one who expects to be recognized as a professional person. One must understand and observe appropriate ethical standards and it is important to cultivate proper understanding of such standards.

The ECPD program "The First 5 Years of Professional Development" is an excellent step in the right direction. Here is opportunity for the engineering societies, the colleges, industrial management, and civic institutions to work

together to aid young graduates in continuing their education and in adjusting themselves to conditions to be met in the practice of their profession.

The present report has been prepared with full realization that the subject refers chiefly to one phase of professional life. An attempt has been made to identify factors that have significant bearing on the specific problem under consideration. Concerted efforts by all concerned with advancement of the profession are required if satisfactory solution is to be found. It is believed that if the recommendations submitted are followed by those to whom they are directed, substantial improvement in the standing of the profession will result. There is no simple solution, but the Committee recommends that:

1. Management utilize the services of engineers more effectively and thereby afford them opportunity for advancement and economic improvement.
2. Management recognize its responsibility to make engineers feel that they are a part of management.
3. Management survey areas of communication, recognition, and salaries and, where found wanting, correct to conform with standards of professional practice.
4. The engineer take inventory of his services and his actions to make sure that he has a professional attitude toward his work.
5. Engineering societies establish and employ appropriate means to maintain high standards of ethical conduct for professional achievement.
6. Engineering societies encourage the professional development of their members and promote proper recognition of the profession.
7. Engineering educators emphasize the characteristics of the profession.

This committee's study treats but one of many problems confronting the profession. It is recommended that Engineers Joint Council continue its study of the problems related to the employed engineer.

Mr. DAVISON. It will be noted that there are two aspects to this problem. There is the long-range aspects, which are exceedingly important. There is also the short-term aspect through which this Nation may stand or fall. The short-term aspect is the one I was just discussing.

It is, of course, impossible to discuss here other than the overall trends. I think it is correct to say that in industry considerable progress has been made and continued progress is to be expected. This results not only from the economics involved, but also from the growing realization of the factors we have discussed here. Never before has there been such a search for the know-how essential to the development and most profitable utilization of technical personnel. I think the record is clear that industry learns quickly and adjusts quickly to inevitabilities and changing times. Much remains to be learned and accomplished but the climate of attitudes necessary to improvement is forming rapidly. There is always the safety valve that the dissatisfied technologist can change employers, and many do.

I think it equally fair to state that, in general, the Federal Government, operating within a very different set of organizational requirements, has been all too slow in adjusting attitudes and policies to the realities of the technical manpower situation. We have already mentioned the fact that many important Government employers of engineering personnel are losing many of their most competent people to other employments. There is little doubt that much of this results from the inability of Federal agencies to compete with other employers of engineers in paying for oustanding talent.

We feel too that the abolition of the professional service in the Classification Act of 1949 has contributed to the situation. Others would know more about the mechanics necessary, but it certainly appears that action is required which would provide authority in the Federal Government to adjust salaries for engineers and scientists in

the employ of the Federal Government to keep them in reasonable alinement with those paid by other employers of engineering and scientific personnel.

At the same time consideration should be given to the establishment of an appropriate professional service under the Civil Service Classification Act for positions which are determined by the Civil Service Commission to truly require the knowledge, experience, and education of the learned professions. This would add to the prestige and recognition not only of engineers and scientists in the Federal Government, but all engineers and scientists, and would be a significant element in improving their employment status.

Now it should be pointed out that military services have advanced considerably in their understanding of the problem of scientific manpower and in their willingness to deal constructively with it. This is demonstrated by the progress which has been made in the reorganization of the military reserve in accordance with the provisions of the Reserve Forces Act of 1955. It is unquestionably largely the result of the capable leadership provided by the Assistant Secretary of Defense for Manpower and Personnel, Mr. Carter Burgess, and by the officials with appropriate responsibilities in the Office of Defense Mobilization and the Selective Service System. However, there are additional improvements which need to be made but they will require, it seems, additional congressional stimulus.

Gentlemen, the largest single underutilized group of young, experienced engineers and scientists cannot voluntarily change their employment status.

I am over 65 years of age. I don't know anything about atomic energy. I would not be competent as an engineer and scientist in atomic energy. But men of the age of my son, between 30 and 35 and 40 know all about atomic energy and are exceedingly active.

These men are all privates—perhaps there are a few corporals—in the United States Army. In number they are not less than 5,000 and probably closer to 9,000. These are men who were inducted during the past 2 years who are currently serving the 2-year tour of active duty. About 5,000 of these are assigned to the Army scientific and professional personnel program. Keep in mind that these men are, for the most part, not what might be called green youngsters just out of school. Many are men with advanced degrees and certainly a majority have had substantial industrial experience. They are in the Army as a result of what we call the universal military service cleanup which resulted in 1953 and 1954 and for a while in 1955 in the more or less arbitrary induction of men who had previously been deferred for reasons of occupation. These, in short, are the very men whose experience would make them extremely valuable in civilian tasks at this time. I am not citing this situation to criticize the Selective Service System. It acted in accord with what it considered to be a congressional mandate contained in the Universal Military Training and Service Act of 1951, a mandate that was discussed during the first session of this Congress. This is an excellent example, however, of the effects that the application of Government authority can have when policy is determined by considerations having little to do with the most crucial facts.

Quite frankly, we and the Army have an honest disagreement about the use to which these men are being put. Our position, the result of postservice interviews with many of them, is that while a few are well used, the majority are wasting a large percentage of their and the Army's time. The Army disagrees. It is a dilemma on the resolution of which little real progress has been made. Lest I be misunderstood, let me say that Engineers Joint Council has always felt that the Armed Forces should have first priority for all the engineers needed as such in uniform. We have, to no avail, suggested the use of the early release authority given by Congress to the Department of Defense, to get these men in industry where they will in our opinion be of greater service to our country.

Representative PRICE. Doctor, you may wonder why the committee has not questioned you on that point, but we developed that very thoroughly on previous hearings. We are glad you also expressed your views on what we consider to be a very important matter.

Mr. DAVISON. Thank you. It may be equitable to insist on the continuation of this situation but we are convinced that it constitutes senseless squandering of our limited technical manpower resources, and is clearly out of phase with the true needs of our times. It should, therefore, no longer be tolerated.

Of the approximately 27,000 young men who will receive bachelor's degrees in engineering this year, about 8,000 will also receive ROTC commissions to be followed by active duty orders for the Army, Navy, or Air Force. It is not generally realized that save for exceptional cases, no attempt is made to assign young officers serving an obligatory 2-year tour to duties for which they have been specifically prepared by their engineering education. The reason offered for this is that the purpose of the required 2-year tour is to give military training to the individual concerned rather than to receive technical service. While we can understand and even sympathize with this attitude, we seriously question its wisdom in these crucial years, particularly with respect to the atomic energy program.

Let me give you one example of what happens. The man who held an important fellowship in metallurgy at Columbia University last year and who received a master's degree in metallurgy last June, according to his professors a very promising young metallurgist, was also an Army ROTC student. He was recently called to active duty to serve his obligatory 2-year tour. Initially he was assigned as a motor-pool officer. I believe this means that he controlled the issuance and accounting of various military vehicles. He was recently transferred to a school where he will apparently learn to be an ammunition officer. Meanwhile, he will make no contribution to the advancement of the field of metallurgy for at least 2 years. This situation exists at a time when most of the barriers to significant breakthroughs in atomic energy application, jet and rocket propulsion are problems in metallurgy. This condition exists when the Army itself requires metallurgists for its own research and development programs.

It seems likely that the military services will need to develop eventually a separate scientific corps, as is done with medical personnel, and to establish a career service. This service should include only persons who by the nature of their scientific and engineering work need to be in uniform.

As a matter of fact, there was reason a year or so ago to believe that the Department of Defense was moving in that direction. In an excellent summary of the situation presented to the 48th Annual Meeting of the Chamber of Commerce of the United States, Mr. Carter Burgess said:

> Through the ROTC we hope to provide an ever widening range of service opportunities. At the present time we are studying the feasibility of a program to encourage development of specialists for the military and defense industry. By specialists we mean engineers and scientists along with linguists, logisticians, financial management experts, and others in fields closely related to our defense needs.
>
> My own feeling is that such an expanded ROTC program in our colleges has become of prime importance. We all know of our shortages in technically trained personnel, both inside and outside the military services.
>
> A redefined and greatly varied ROTC program would work first to the advantage of the military but would also have to be considered as a first-class training ground for defense industry as well.
>
> The Department of Defense intends to continue its careful reappraisal of the ROTC with the intention of integrating it more closely with the overall defense program. In addition to other considerations, we will need a large production of ROTC graduates to fill requirements for the 6-month active training and Ready Reserve program.

Since nothing further has been heard regarding this development plan, we can only assume that for some reason this excellent conception of the problem and realistic approach to it has been discarded. We believe the need for it has actually increased.

Many groups in our society have contributed toward the productivity and the material welfare of this country and there is no intention here of minimizing their contribution but it is I believe true that the engineering profession is the only major group whose primary reason for existence is to increase productivity and thereby to continue the development of our strength and abundance. There would be no engineering profession and no need for engineering schools if all new machines, structures, circuits, and processes, all new plants and systems, all new highways, chemical works, steel mills, airplanes, instruments, and so forth, were merely replicas of those already in existence and were acceptable at the same cost and performance. However, it is clear that the basic sine qua non of our economic and national security programs is dissatisfaction with what we have and a continuing intense drive for improvement. The Federal Government can make an important contribution to the pace of our technological process by insuring that the necessary application of Government authority does not seriously impede the development and utilization of the very, very small fraction of our population who are crucial to our continued technical progress.

It is, thank the Lord, the nature of our system of government that ultimately Government policy has to have the understanding and approval of our people. I am old-fashioned enough to believe that the most perfect mirror of public opinion in this country is still the Congress of the United States. Using this as the basis of judgment, I think it safe to say that we understand our problems well enough to move forward to accomplish what needs to be done.

On behalf of the Engineers Joint Council I want to thank you for the opportunity to discuss these problems with you. Needless to say, we are always available to render whatever assistance you feel you may need, either as individuals or as members of the engineering profession.

Representative PRICE. Thank you very much, Dr. Davison and Mr. Cavanaugh. May I say that the committee is very deeply interested in the matter of the proper utilization of scientific and engineering manpower within Government agencies. We have developed that very thoroughly throughout the hearings. I am very glad that you elaborated and emphasized your concern over these matters.

Unfortunately, we have a rollcall in the House now so it is necessary that the committee adjourn.

We will stand adjourned until 1:30.

(Thereupon at 12:15 p. m., a recess was taken until 1:30 p. m., the same day.)

AFTERNOON SESSION

Representative PRICE. The committee will be in order. This is a continuation of the hearing of the Research and Development Subcommittee of the Joint Committee on Atomic Energy to hear testimony on the shortage of scientific and engineering manpower, particularly as it affects the atomic energy program. The committee is privileged to have sitting with us this afternoon, Representative Moulder, of Missouri, who is an important member of the House Committee on Interstate and Foreign Commerce, which has considerable to do with some of the ideas that could possibly generate from the testimony we are taking.

The first witness this afternoon will be Dr. Cherry L. Emerson, National Society of Professional Engineers.

STATEMENT OF DR. CHERRY EMERSON, NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS

Dr. EMERSON. Mr. Chairman and members of the subcommittee, I am Cherry L. Emerson, of Atlanta, Ga.; and I appear before you to present the comments of the National Society of Professional Engineers on the subject of your current hearings. We appreciate very much the invitation of Chairman Price to participate in these important deliberations, and I would like to express the regret of our society's president, Mr. Allison C. Neff, of Middletown, Ohio, that conflicting engagements made it impossible for him to accept the invitation personally.

Acting in Mr. Neff's stead, I would state for the record that my background related to the subject of the hearings includes degrees in mechanical and electrical engineering and registration as a professional engineer. I was employed as a professional engineer for 5 years with one of the largest electrical manufacturing corporations and as an engineering executive for 5 years with one of the southern power companies. For 26 years, I was associated with Robert & Co. of Atlanta, a well-known firm of consulting engineers, with the position of chief engineer, vice president and president. I left this firm in 1945 to become dean of engineering, Georgia Institute of Technology. In 1948 I assumed the position of vice president of Georgia Tech and served in that capacity until my retirement July 1, 1955. At that time I became associated with an Atlanta architectural firm in an engineering consulting capacity. During my continuing membership in the National Society of Professional Engineers, I

have served as a vice president and as a member of the National Affairs Committee, among others.

The National Society of Professional Engineers has a membership of 37,000, all of whom are registered under the engineering registration laws which are in force in all of the States and other jurisdictions of the United States. The individual memberships are through 41 affiliated State societies, and through the 350 local community chapters of the State societites.

We have long been concerned, as have other organizations, with the growing problems associated with the development of adequate numbers and high quality of the Nation's engineering personnel to serve what at times seems to be an insatiable demand by industry, governmental organizations at all levels, including the needs for the foreign technical assistance program, and, particularly, those organizations responsible for research, development, and production for national defense. In addition, this subcommittee is rightly concerned with the technical manpower needs which are certainly developing rapidly in the new field of atomic power.

This subcommittee is to be commended for giving its time to this problem, and for focusing national attention on a matter which has implications far beyond the interests of the engineering and scientific professions—implications which involve every citizen in terms of national survival if war should be thrust upon us. More hopefully, the questions before you involve the development and maintenance of the very best in defensive strength so that such strength may prevent world disaster.

The statistics about the problem are known to all. We shall not repeat what Chairman Price referred to as "the gloomy statistics" in his excellent preface to the report Engineering and Scientific Manpower in the United States, Western Europe, and Soviet Russia. We take it that this subcommittee is particularly interested in the testimony of organizations with respect to what is being done to alleviate the problem, and, more importantly, what can be done.

Undoubtedly, this subcommittee knows that the problems are not simple, and are not susceptible of easy answers. In the following comments, we have tried to identify the major aspects of the overall problem and to offer what we hope are constructive thoughts.

The problem divides itself into two parts: (1) the immediate; and (2) the long range. We recognize that colleges of engineering and science are immediately in need of considerable help, particularly in their graduate schools to produce high-level scientists and engineers. It might be desirable, however, to deal first with the long-range aspects of this program.

INTERESTING YOUNG PEOPLE IN ENGINEERING AND SCIENTIFIC CAREERS

We all hope and pray that the day will never come in this country when a person is directed by governmental authority to engage in a certain field of study or work in a particular occupation. We all hold dear the idea of individual choice for our life's work. Our approach to inducing young people into certain courses of interest and need must be through incentives and an appeal based on a showing of the opportunity to make a worthwhile contribution to society with adequate rewards.

The National Society of Professional Engineers has engaged in work of this nature for many years. We have developed a relatively simple booklet which is designed to answer the questions young people most often ask about an engineering career. In addition, we have developed a somewhat more elaborated printed discussion for the use of parents, vocational guidance counselors, teachers, school administrators, and others who may guide the young people in choice of a career.

These are made available to anyone interested without charge, and the demand has required the distribution of approximately 40,000 to 50,000 of the pamphlets a year. Much of the demand comes about as the result of the nationwide publicity generated throughout the country during the observance of National Engineers' Week, which is sponsored by the society. This observance has had the enthusiastic cooperation of industry, commercial organizations, governmental agencies, educational institutions, and the press. It has reached almost everyone who reads newspapers and magazines or who listens to radio, watches television, or attends civic meetings. The observance has been stimulated each year by a message from the President of the United States, and by proclamations of governors and mayors. We are pleased too that members of Congress with engineering backgrounds have participated.

This is only one method of stimulating interest in an engineering career. Many organizations have career stimulation programs of various types, including the organization of engineering clubs in the high schools, speakers at career guidance days in the schools, conferences with parents and teachers, et cetera. Many of our local community chapters sponsor and participate in such programs. We suggest that this type of work must be continued and expanded by private organizations. We are confident, based on past experience, that such programs will receive the cooperation of the press, radio, and television.

Last year our society president sent a special message to all the newspaper publishers in the United States calling attention to the mathematics and science situation in high schools and asking for their assistance in publicizing the needs. The response was most favorable and produced many editorials, feature articles, news stories dealing with the situation nationally and in the local communities in terms of available educational facilities in engineering-related courses and teaching personnel.

INDUCEMENT THROUGH PROFESSIONAL STATUS

Career planning involves more than the opportunity to serve society and to obtain adequate rewards in a monetary sense. It also includes a morale or prestige factor, particularly for those in a professional field, such as engineering. Unfortunately, too often in the past, and to some extent it is true today, engineers and scientists have not been given full professional recognition. For the young person thinking of a professional career, it is important that a proper climate be established and made known. Our society is engaged most actively in a broad range of programs which deal with this objective for engineers in all fields of employment.

The need for this type of recognition is just as important to Government as to industry or in private consulting practice. For this reason, we suggest that this subcommittee may be interested in appropriate corrective action on the part of Congress to restore to professional engineers and scientists in the Federal service the professional classification which was lost when such personnel were placed in the general schedule in 1949. Representatives Moss and Gubser of the Post Office and Civil Service Committee have announced that they are planning to introduce bipartisan legislation to establish a new professional schedule for engineers and scientists with appropriate grades and salaries.

Such action on the part of the Federal Government would undoubtedly exert a strong influence on other governmental units and on private industry.

Representative PRICE. May I say that possibly some of the testimony we have been receiving through our hearings may contribute to the support of the type of legislation that Representatives Moss and Gubser are working on.

Dr. EMERSON. We certainly will do everything we can.

THE NEED FOR SCHOLARSHIPS AND OTHER FINANCIAL AID

The members of the subcommittee are aware, of course, of the large number of bills now pending in Congress which would authorize Federal scholarships, or loans in some cases, for the purpose of providing the financial means for young people to engage in formal study of engineering or scientific subjects. All of these bills are predicated on the belief that the failure of many of our young people to engage in such study flows from the lack of financial means. There can be no question that the lack of funds is often the cause of promising young people not obtaining higher education.

However, we think that there is insufficient evidence available today to indicate clearly whether there are enough available scholarships to meet the needs of those who are qualified for and would take engineering or scientific courses except for financial reasons. In any event, it would appear that there is insufficient information available and publicized regarding scholarship opportunities. Perhaps it would be in order for the National Science Foundation to compile as complete a list as possible of engineering and scientific scholarships and give it wide publicity through normal channels of Government and through the cooperation of engineering and scientific organizations.

Representative PRICE. At that point I would like to direct an inqury to my staff. I do not remember when the National Science Foundation testified whether they presented such a list. Did they give us a list of the various scholarship funds that are in operation on the part of industry or any other sort?

I have been informed not.

I think you have a good suggestion. I think we should request the National Science Foundation or some appropriate office—the Office of Education or someone who might have such information—to supply us for the record the information on which you have just put your finger. I think it is very important for us to have. I think it should be better publicized and better known to prospective applicants for careers in the scientific and engineering fields.

Dr. EMERSON. The list has grown very rapidly in recent years.

We are aware of the strong sentiment of many, including congressional leaders, that financial aid by the Federal Government should be delayed no longer and that in the long-range interests of national defense a Federal scholarship program should be instituted as soon as possible. It must be made known to the subcommittee, however, that there are many of the engineering profession, including a number of engineering educators, who feel that a Federal program should not be instituted at this time. To the contrary, they feel that every effort should be made to stimulate the needed funds from other sources.

There are some things, however, which we feel can be recommended with general support in this area. One pending group of bills calls for an amendment to the tax laws to permit a 30 percent credit against individual income tax for amounts paid as tuition or fees to institutions of higher learning. Such action would undoubtedly make it possible for some parents to send their children to college who cannot now afford it. Within recent days there have been published reports that the Federal Government may conclude the present fiscal year with a substantial surplus. If so, and if Congress is disposed to reduce tax burdens based on improved Federal revenues, it may be desirable to consider applying some of the tax relief in the manner indicated, and at the same time give encouragement for more enrollment in the colleges and universities.

Representative Ruess of Wisconsin has introduced a bill which would permit corporations to deduct from their tax returns an additional 5 percent for contributions to accredited technical schools or schools of engineering. The corporations are, of course, one of the important sources of funds for engineering and other institutions of higher learning. The statistics indicate that relatively few corporations are now giving amounts equal to the permitted 5 percent for educational and charitable purposes. However, for those few corporations which have made gifts to the limit of the allowable deduction and would give more if permitted to do so on a tax-deductible basis, consideration should be given to such legislation as a further inducement for private financial support.

THE SHORTAGE OF HIGH SCHOOL TEACHERS

We are sure that the subcommittee has heard of the very serious problem that the elementary and secondary schools are woefully short of qualified teachers in the mathematical and physical science fields. The engineering educational institutions as a result receive far too many freshmen engineering students who lack basic education in subjects necessary to an engineering career. It does us little good to decry this situation which is not the fault of the schools, but is directly related to the teacher salary problem. What can be done about it? We must somehow provide the funds necessary to attract and retain competent teachers in these subjects.

The subcommittee might like to consider that the Federal Government could provide fellowships for graduates in engineering, physics, chemistry, or mathematics. These men would obligate themselves to a period of 3 years to teach courses of general science and mathematics in high schools. Their salaries would be supplemented by Federal appropriation beyond the amount normally paid high school

teachers. In addition, they would be eligible at the end of their 3 years of teaching to a fellowship which would enable them to attend the institution of their choice for 3 years and obtain a doctor of philosophy degree in their field of specialization. This cost would also be borne by the Federal Government. At the end of this period, there would be several thousand young men who had achieved the highest collegiate degree and who would have had 3 years of teaching experience in high school and who would make an excellent pool of talent for college faculties.

Undoubtedly, many with this background would wish to continue their teaching career. This would serve the double purpose of supplementing science teaching in high school and provide a future nucleus for college faculties. It would probably be desirable that this program be administered by the National Science Foundation.

Another suggestion has been made that assistance on this problem might be given by industry and other users of engineering services by making available on a part-time basis engineers and scientists who can devote a few hours a day, or week, to teaching duties. This proposal has a number of complications, and our society, together with other interested groups, is currently studying the feasibility of this proposal. If this seems practical, the local chapters and State societies of our organization will conscientiously work with local boards of education and industry to make such personnel available.

PROBLEMS OF THE ENGINEERING SCHOOLS

Recently, Dean John W. Whittemore of Virginia Polytechnic Institute, in his capacity as chairman of the engineering division of the American Association of Land Grant Colleges and State Universities, completed a survey which reveals a widespread shortage of teachers and facilities in the engineering schools. This survey shows that while most engineering schools are continuing to admit all qualified applicants, some are already turning away qualified students because the college lacks faculty, and the necessary classroom and laboratory space for instruction. The retention of qualified teachers in the colleges has become a major problem because of the higher salaries offered by industry which the limited financial resources of the schools cannot match.

We would like to stress as strongly as possible that if Congress should adopt a Federal scholarship program, consideration should be given to the fact that tuition does not cover the full cost of the education. A substantial increase in enrollments will mean, among other problems it creates, a further deterioration in the financial ability of the university. Any large-scale scholarship program should provide adequate grants to the school itself to cover the deficit between tuition and total educational and operating costs.

In the August 1955 issue of our society's magazine, the American Engineer, appeared an article by me entitled, "National Defense Begins in the College." I venture to mention this because there is a point made therein which is fundamental to the problem before this subcommittee and pertinent to a discussion of the problems of the colleges. The point is based on the undoubted fact that we must be interested in the quality of our engineers and scientists as well as the numbers turned out each year. More recognition should be given to

this vital fact, and in doing so, we must recognize that under today's complicated technology, graduate work for those qualified for it is a necessity to develop the kind of top-level scientists and engineers who can generate new ideas in uncharted areas, such as atomic energy. If we concentrate all our attention on producing large numbers of engineers and scientists, and neglect the gifted who are qualified for advanced work we are heading for technological disaster.

In that article I said:

> Of the 1,800 colleges in the country, perhaps between 100 and 200 have sizable graduate schools capable of conferring sound doctoral degrees in engineering and science * * * Such graduate schools cannot be established overnight, regardless of the amount of money made available. It would be well to nurture and expand the schools that have already proven their worth.

I noted that graduate work is the most expensive type of university education. The colleges have recognized the paramount importance of turning out a larger number of well-educated Ph. D.'s, and have striven mightily against great handicaps, but the iron pressure of inadequate budgets has forced them into many compromises. They have accordingly welcomed the opportunity to obtain sponsored research where all, or part, at least, of the cost can be earned by their own efforts.

Many of the research contracts come from the Federal Government. This would be all to the good, but we are faced with the anomaly that the more Government research performed, the weaker become the colleges financially. This results from the fact that the Federal policy is that research contracts should be given to colleges on the basis of the so-called dollar in, dollar out theory. That is, the Government pays only the actual cost of the research itself. Every business has indirect costs as well as the direct costs of labor and material, and if that business does not recover its indirect costs plus a profit, it will not long exist.

Again, quoting from my article:

> The bulk of the $2 billion or more being spent by the Government for research is funnelled through the Department of Defense. The part of this which is farmed out to the colleges is theoretically contracted for on the dollar in, dollar out basis. An allowance is made for indirect costs as well as direct costs. The allowance, however, is seldom sufficient to repay the indirect costs of the institution. After various studies and negotiations have been completed by Government personnel to determine the indirect charge allowance, it is still possible that there will be disallowances for bills rendered although the funds were actually spent in performing the contract. The total result of the negotiation is to reduce the income from the project so that very rarely does the institution recover even the money it has spent to do the work.

If it is consistent with your subcommittee's policy, I will submit the entire article for the record.

Representative PRICE. The subcommittee would be very glad to have the article.

Dr. EMERSON. Thank you very much.

(The article referred to follows:)

NATIONAL DEFENSE BEGINS IN THE COLLEGE

By Cherry E. Emerson, P. E., former vice president and dean of engineering, Georgia Institute of Technology

In a way of thinking, the world situation has become simplified. There are two hostile camps—the Communists headed by Russia, and the free world headed by the United States. Other countries fall into the relationship of allies,

satellites, associates, or within one of the two spheres of influence. Reliable authority, including the President of the United States, holds that this hostile balance may continue for a generation or even 50 years, unless world war III intervenes. In this event, both camps may be substantially destroyed.

Our best news analysts think the possibility of war is rather remote. The United States will not precipitate a war, basically because it is a Christian country, and realizes that provoking war unleashes all of the forces of evil. The Russians do not have the same deterrent, but control of that country is now quite apparently in the hands of the military forces, and this group will not start a war unless they are quite convinced that they will be able to win it and with some possibility of survival after winning. It does seem logical, therefore, to anticipate quite a long period of stalemate with an uneasy and unpleasant truce.

On the basis of these general observations, we make certain comments. Some of the assertions will undoubtedly seem dogmatic because space does not permit an explanation of the reasoning which has led to each specific conclusion stated; too, there are exceptions to practically all of the statements. But the statements are generally sound, and are supported by evidence from sources that are quite dependable.

We have so many avenues of public information and the experts on each have been so concerned with the possibilities of conflict that even the layman has obtained a fairly good idea of what another world war would be like. The various bombs of fission and fusion have provided explosives so much more powerful than the old style TNT that a new war dimension is produced. The United States is capable of delivering in 1 month's time explosives which would be equivalent to all those delivered by all the air forces of all the combatants during a year of World War II.

The United States has lost its uniqueness in possession of nuclear-energy devices, but still is in a position of immense quantitative superiority to its enemies. The problem has now become one of delivery, whether by plane, artillery, guided missile, rocket, or submarine. The British are just now criticizing their Government for planning a large increase in the production of atomic weapons and in the strategic air force, on the argument that the money should perhaps be better expended on research in guided missiles for the delivery of bombs to be provided by the United States. Many Britishers feel that money should be spent on brains rather than on manufacturing facilities.

While our own development is to a considerable degree shrouded in military secrecy, we do know that arrangements are being made to test guided missiles over a 5,000-mile range, and that research is progressing on the intercontinental ballistic missile. We know from our *Nautilus* that atomic propulsion has added importance to the submarine, and that there is a terrific competition between measures and countermeasures for the detection of submarines.

For concealment, undersea craft have been given a rubber coating which defies the old methods of search, but recently we have been relieved to hear that certain new methods of detection are being perfected which will enable us to locate them with the same ease that radar detects hostile aircraft. Work goes on with serious purpose about the establishment of an artificial satellite perhaps a thousand miles above the earth from which in isolated safety the world could be patrolled and controlled.

All of these activities and many others too numerous to catalog, indicate that the new military potential is largely dependent upon science. There is a tremendous race between the creative ability of American scientists and Russian scientists. It is reasonable to say that the survival of our country depends upon maintaining our lead in this race. We have no reason to doubt that if the Russians surpassed us in scientific accomplishment, there would be nothing in their philosophy to deter them from an H-bomb attack on our airfields and atomic installations. And, if they achieve superiority they will almost certainly be aware of it.

Gradually, and without complete realization, we have come to the point where our magnificent industrial productive capacity might be considered obsolete. This same question could be raised about our great fleet and even, perhaps, the existing aircraft of our Strategic Air Command. We are coming to see that as a first consideration our scientific ability is being pitted against that of the Russians, and that the stake for the winner is control of the world.

With very great reluctance, we devote the abilities of the scientists in industry, Government, and our universities to problems of war, and only because self-

preservation is the first law of nature. We have stated that no matter how greatly our scientific potential may exceed that of the Russians, we will not instigate a preventive war. It is a very terrible thing that we cannot believe the same about the Government of Russia, and yet our intelligence cannot be smothered by wishful thinking.

There is, of course, a small though long-range chance that Russia's motivation might be changed. Whether we recognize it or not, our democracy and our liberty rest on the basis of the belief in religion and particularly on the Christian ethic, and religion still survives in the Soviet Union despite the vigorous official campaigns that have been conducted against it. It may well be that therein lies that necessary motivating force.

Moreover, the Russian leaders have at least been giving lip service to a desire for world peace in recent weeks. The summit meeting at Geneva, which has just been concluded, is the foremost current example of this change of pace. And further friendly overtures have been made in the granting of visas to such groups as the American farmers now touring Russia while a group of Soviet agricultural officials are being received in Iowa. We can only hope, while continuing to be as alert as possible, that these are indeed signs pointing to improved world conditions. Meanwhile, however, we must bolster our scientific efforts.

On the thesis that we are dependent upon science for survival, let us take a brief look at our scientific situation. The striking thing is that our scientists are so few. They probably represent at present about one-tenth of 1 percent of our population. While it is common knowledge that engineers are in very short supply, the lack is not so devastating as the shortage of able scientists. Practically every research organization in the country is searching for talent, and is endeavoring to proselyte the able members of other organizations. Industry, because of its greater material rewards, is able to take scientists away from Government laboratories and from colleges and universities. It has exercised this strength without much regard for the results to the general good. Many magnificent Government laboratories with millions of dollars worth of equipment are so lacking in operating talent that their contributions are ineffective. The faculties of colleges have been a particularly fertile field for the inroads of industry. As a single example, the research director in a southern university was employed not long ago by industry at three times the salary he was receiving from the college. This process continues with deadly effect.

Magnificent Government installations are neutralized, and colleges are rapidly losing their ablest and most creative individuals. It would be natural to assume that, as intelligent people, we are making every effort to supply the shortage, not only in scientists, but also in engineers. This, however, does not seem to be the case. We are told by no less an authority than the National Science Foundation that Russia is educating a great many more engineers and scientists than we, and we would be foolish to assume that the quality of the engineers and scientists produced by the Russians is greatly inferior to our own. We should remember that immediately fololwing World War II, the Russians were very active in collecting the best of the German scientists and removing them to Russia.

The operation of selective service is helping to intensify the shortage by drafting young engineers and scientists from industry and the graduate schools. They are being taught the manual of arms and other ancient games while they should be learning the rudiments of scientific research and acquiring the competence to contribute to the winning of the scientific race. They should all have their military service deferred, not to make them a favored class, but to help our chances of survival. If our young technical people must be put in uniform, they should all be assigned to Government laboratories compatible with the training they have already received.

Thoughtful people, confronted with a shortage of anything, study the sources from which that thing is to be obtained. As for scientists, there is one source and one source only, and that is from the graduate schools of our colleges and universities. Mathematicians, physicists, chemists, and engineers who are competent to do research and development work cannot be produced in any other way. Skilled mechanics can come up through a course of apprenticeship; businessmen can be trained in the school of experience; but scientists must have had the advantage of a formal education.

As an approximation, we might say that the best brains in our high-school graduating classes go to college. The best brains among our college graduates are accepted as candidates in the graduate school. The best brains in this group come out some 3 years later with a Doctor of Philosophy degree or its equivalent. These are the men who will carry on the future scientific ac-

tivities whether directed toward peace or war. This long process between high school and active participation requires 6 to 10 years, and the period cannot be materially shortened. This activity of sieving and selecting is somewhat like the refinement of U-238 to U-235.

The selective process is not always accurate, but in general the most able young men in the field of science are those who have earned doctor of philosophy degrees from our better colleges. It is to be remembered that two mediocre scientists are not the equivalent of one who is really able and creative. Quality is even more important than quantity.

Since it would appear that the survival of all of us depends upon the quality and quality of the product of these graduate schools, it is to be assumed that they are given every possible aid. We should expect the full resources of this great country to be devoted to their improvement, and take it for granted that their leaders and administrators are regarded as the most important and useful people in our country. The facts, however, totally fail to back up these assumptions. We have the grim paradox that the sole sources of the priceless ingredient which could save our country and our lives are not only neglected by and large, but also are subjects for policies which make it more and more difficult for them to produce the priceless ingredient at all.

There are in the United States approximately 1,800 colleges and universities. Over half of these are now operating at a loss. Approximately one-half of these institutions are State supported, the others privately supported. Some of the State-supported institutions are financed with reasonable adequacy; most of them, however, except in the North and Middle West, are being starved by small State appropriations, while the privately supported institutions are in a truly deplorable condition financially. The reasons for this are almost self-evident. Since 1940 practically everything that the colleges buy, from lead pencils to cyclotrons, has doubled in price. The returns from the investments which constitute their endowments have been almost halved. We accordingly have a ratio of operation which is 4 to 1 more difficult than some 15 years ago. The colleges are unable to pay their professors much more than a living wage. In fact, some professors with large families are unable to buy their own product; that is, they are hard put to provide their sons and daughters with a college education. Moreover, they see their graduates, because of the demand for engineers, going out into industry at a beginning salary almost equivalent to the regular earnings of the professor who graduated them. This is indeed an anomaly.

We smugly consider that our scientists and engineers are better educated than the Russians. How we arrive at this conclusion is rather remarkable. The colleges are losing their best and most creative minds to industry, and the college pattern is losing its effectiveness in many ways. College people are being harassed with charges of being communistically inclined, and are being forced to sign loyalty oaths and security questionnaires which trench on the freedom and mental serenity of the individual. Professors are frequently regarded in the community as nice but futile people who are to be tolerated for the sake of threadbare intellectual accomplishments that have no practical utilization.

The colleges would probably not admit it, but the quality of instruction today is not as good as it was 10 years ago. Ten years hence it will be still less adequate, unless some steps are taken to improve conditions. The future does not promise improvement. The great increase in the younger population is now engulfing the grade schools and by 1970, unless something is done to limit college admissions, it will have increased college enrollment by, perhaps, 75 percent. In Russia, continually greater assistance is being given to mathematics and the rudimentary sciences in the secondary schools. This helps prepare the pupils for further education as engineers and scientists. In our preparatory schools there is a great dearth of such instruction. One evidence of this is that the number of college students completing schoolteaching certificate requirements in science and mathematics in 1954 showed a major decline from 1949. Mathematics was down 50.6 percent and the other scientific studies were down 56 percent. This means that high-school students will come to college less well prepared than ever for engineering and scientific courses, and that the faculty to teach them in college will probably be not only overworked, but also deteriorated. We have not forgotten that some constructive idea should be provided along with any criticism of existing conditions. One suggestion would set up a form of fellowships to attract mathematics and science teachers to secondary and preparatory schools. College graduates who took positions as teachers in these subjects might

have their salaries supplemented for 3 years at $1,000 a year. At the end of 3 years' teaching, they could be given a fellowship worth $4,000 a year for work in the graduate schools of any university they might select. During that period they would do no teaching. At the end of 3 years, most would have attained the doctor of philosophy degree, and would be available as instructors for other colleges.

The greatest single problem of a young man taking up teaching as a profession is that he cannot attain the highest ranks in college unless he has an advanced degree. The time and expense involved in getting this degree form a tremendous obstacle which most have great difficulty in surmounting. If he knew that by teaching in the secondary school for 3 years, perhaps even without any supplement, he would be enabled thereafter to purpose his scientific studies, and that accordingly he would have no handicaps to his promotion in the teaching profession, assuming he had the ability, he would be greatly attracted.

If we had an additional 10,000 experienced men under 30 available for the faculties of engineering colleges and the scientific departments of the universities, it would strengthen these faculties tremendously. We would have, say, 12,000 men teaching in secondary schools, each receiving a supplement of $1,000 apiece for 3 years. We would have perhaps 10,000 of them receiving a fellowship of $4,000 per year for 3 years; so the investment in each of the 10,000 would be $15,000. To produce this 10,000 we would have an annual cost of $156 million, which is substantially less than the cost of 1 aircraft carrier. This plan would not only help to improve the quality of students entering colleges, but would, over a period of years, supplement, stimulate, and improve the faculties of our colleges and grade schools, and while the figure 10,000 is used—it could well be expanded by multiples of that figure.

Of the 1,800 colleges in the country, perhaps between 100 and 200 have sizable graduate schools capable of conferring sound doctoral degrees in engineering and science. These constitute the actual sources from which future generations of scientists will come. Such graduate schools cannot be established overnight, regardless of the amount of money made available. It would be well to nurture and expand the schools that have already proven their worth.

The graduate schools, which are producing scientists and top-level engineers, must carry on research to educate their charges properly. No amount of course work from texts can substitute for actual experience in conducting or helping to conduct experimental work along the frontiers of scientific knowledge. The laboratories where research can be done are quite expensive, and the students must work singly or in small groups. They require the guidance of more experienced faculty members. This thesis guidance, or direction of nonthesis experimentation, demands time and thought of a large number of able professors, each teaching a small number of students. There also exist requirements for specialized equipment and supplies which are frequently costly. All of this adds up to the fact that graduate work is the most expensive type of university education. The colleges have recognized the paramount importance of turning out a larger number of well-educated Ph. D.'s, and have striven mightily against great handicaps, but the iron pressure of inadequate budgets has forced them into many compromises. They have accordingly welcomed the opportunity to obtain sponsored research where all, or part, at least, of the cost can be earned by their own efforts.

Industry has begun to place more research contracts with the colleges, even though it fears to lose some patent benefits thereby. By and large, however, industry is not much interested in basic research which, of its nature, offers little prospect for producing an immediate profit. Another aspect of the quid pro quo is the concentration of such work in those colleges which are already well supplied, and even the major utilization of the half dozen or so which are actually surfeited at presented. There is no doubt that these favored few have great abilities to produce results for their clients, but what we are dealing with here is the education of graduate students.

Although the distribution of research contracts by the Federal Government is more widespread, it, too, tends to favor the stronger and larger institutions so the concentration of research is accentuated. Most of the Federal Government research is done by the armed services, and far too little of this is devoted to basic research, and far too much to the production of weapons. The latter is vitally important, but can well be done by industry; but due to its whole philosophy, industry finds it difficult to continue for years the search for knowledge for its own sake, without being concerned with the financial return. The university, on the other hand, offers an ideal climate for the propagation of basic research

There were great hopes that the National Science Foundation might solve the rin problems of overcentralization and the preponderance of applied research er basic, however, the motors of the Foundation have never received enough nancial fuel to get the craft off the ground. Why this is so remains a mystery.

We have dealt at some length with the fact that our survival may depend upon e success of our graduate schools in producing able young engineers and ientists. We have just noted that research and experimentation is an abso-tely necessary tool in their operation. So we should expect our Government to se its sponsorship to aid and strengthen our colleges which have been weakened changes in our economy.

Strange to relate, this is not happening. In fact, the more research the colleges the weaker they become financially. Congress has developed a policy that esearch contracts should be given colleges on the basis of the so-called dollar in, ollar out theory. That is, the Government would only pay the actual cost of e research itself. Every business has indirect costs as well as the direct costs f labor and material, and if that business does not recover its indirect cost plus profit, it will not long exist.

The bulk of the $2 billion or more being spent by the Government for research funneled through the Department of Defense. The part of this which is rmed out to the colleges is theoretically contracted for on the dollar-in, dollar-t basis. An allowance is made for indirect costs as well as direct costs. he allowance, however, is seldom sufficient to repay the indirect costs of the stitution. After various studies and negotiations have been completed by overnment personnel to determine the indirect charge allowance, it is still ossible that there will be disallowances for bills rendered although the funds ere actually spent in performing the contract. The total result of the negotia-on is to reduce the income from the project so that very rarely does the stitution recover even the money it has spent to do the work.

The agencies, other than the Armed Forces, seemingly vie with each other forcing the universities to carry the greatest possible part of the cost of oing research for them. Some sponsors ask the college to share the direct ost of labor and materials. Others, such as the Atomic Energy Commission, llow direct costs and 9 percent as indirect for those projects initiated by the esearch institution, whereas the actual indirect cost is usually from 50 to 100 ercent of direct man-hour expense. The National Institute of Health allows percent of the total expenditure, and even the National Science Foundation, hich was supposed to be the savior of the colleges, allows about 25 percent oward indirect cost. The others have various demands, all onerous.

Through this policy, the colleges already on the road to bankruptcy, must se part of their slender resources to help defray the cost of research. The esearch itself may prove of great value and worth many times its cost in results btained, but it may have a subsidiary value exceedingly more important. he research helps train graduate students on whose competence the survival f the United States may well depend.

Now, the basic policy of the dollar in and dollar out as applied to educational nstitutions is the height of folly. The Government should be seeking avenues hrough which it could aid education of all kinds. Even on the least altruistic f all bases, it is only reasonable to aid that education which is producing the roduct for which we have the greatest need and which is now in shortest upply. Very little investigation will convince the most skeptical that unless ur scientific potential continues to exceed that of Russia, we will have no axpayers, no Congress, and no educational institutions to starve.

Why not, in the name of commonsense, pay an indirect rate of 200 or 300 ercent on research contracts? This would pump a little tax money into those nstitutions that can return an output of trained men as well as the answers o the problems submitted to them.

Such a plan would favor those colleges now doing research for the Govern-ent and others that might be competent to do it. What better means could e found of locating those institutions which can do most for the long-range efense of our country?

The increased cost of payment for research contracts would still amount to ess than the investment in one atomic submarine, and it would be of very great elp to the most useful, in a material sense, of our 1,800 educational institutions.

To sum up the matter, we have moved rather abruptly from the machine ge into the age of science. Since warfare is the sum of the total material power f a nation focused on destruction, we must recognize that our armed might also determined by our scientific ability and that massed tanks are only a ood target for one fusion bomb.

We look about and see only a small handful of able scientists who can pro
duce the new miracles. Our enemy, apparently more concerned that we, t
striving continually with smaller resources than our own to produce mor
scientists and engineers, and apparently is succeeding in outdistancing us.

We find that we have 1 source and 1 source only—our graduate schools, fro
which more scientists and engineers may be obtained.

We should realize almost with a sense of horror that we are pursuing policie
in industry and government that are not only diminishing the quantity, bu
deteriorating the quality of their output. The raw material which our college
receive as entrants is becoming progressively less suitable and the productiv
facilities of these colleges in men and material are becoming less adequate, whil
their leadership is suffering from financial starvation.

Perhaps it is time that we should follow the pattern of British thinking
and consider whether it would not be more logical to spend a large portio
of our tax money on brains rather than on hardware which is to some degre
becoming obsolete. Let us use a scientific approach in studying the problem

Dr. EMERSON. Certainly one of the most helpful things this subcom
mittee could do to help meet the problems of the universities is to us
its influence to bring about a more generous and realistic policy on th
part of the Federal agencies in connection with Government-sponsore
university research.

A very pertinent and timely suggestion, which could be implemente
immediately, has been made by Admiral Rickover. He suggested tha
industry might take some of its engineering and scientific personne
and return them to college faculties on a leave of absence basis fo
perhaps 2 or 3 years.

To add some amendments of our own, it would probably be desirabl
to select those men in industry who had had previous experience i
college teaching. These men would not be drawn from those areas o
industry now producing systems or weapons of defense for the Unite
States, but from areas contributing to the comfort, convenience an
amusement of the public. It will probably be necessary to provid
incentives to industry to make this program workable. The selectio
of such incentives can probably be made best by this subcommittee
but, as a suggestion, twice the individual's present salary might b
allowed as a business deduction from taxable income of the compan
providing his services.

It is, of course, understood that the individual would continue t
draw the same salary as he had been enjoying in industry. These me
could probably be utilized by the colleges in their graduate teachin
and research, particularly for the guidance of these required for Ph. D
degrees.

Let me say that General Sarnoff dealt in general with that idea a
some considerable length. He has taken up the idea and developed i
very effectively.

As we indicated in the beginning and as we are sure that this tes
timony has developed, this is an exceedingly complicated problem
with many facets not susceptible of immediate solution. It is also
apparent to us, as we think it is to this subcommittee, that the Gov
ernment and the Congress of the United States will be increasingly
interested, involved, and responsible in working toward solutions
and improvements. For this reason, we think it would be pertinen
for Congress to give serious consideration to the suggestion of Senato
Thye and the others who have cosponsored the recent bill to establis
a congressional joint committee on scientific research to deal specifi
cally with the problem of training adequate manpower in the scien

ic and technological fields. As we understand this proposal, the nt committee would be bipartisan and would be nonlegislative. is would be desirable on both counts as it would permit such a nt committee to engage in high-level studies with adequate staff, d, particularly, to relate the technological manpower problems to e overall legislative problems handled by the other committees and the Congress as a whole.

Mr. Chairman, we hope we have developed some points pertinent the hearing which deserve consideration; and we hope that we ve made some suggestions which are worthy of your further study. e National Society of Professional Engineers, along with the many ner fine organizations which have appeared before you, deeply de- es to cooperate in every possible way to aid your subcommittee in e important task it has assumed. We appreciate the opportunity to pear before you and to try to help develop some answers to a prob- n which is paramount to our national life.

Representative PRICE. Thank you very much, Dr. Emerson. While regret that Dr. Neff found it impossible to be with us this after- on, we certainly found a new and very able replacement. You de a very fine statement which will be helpful to the committee. We have found as we have gone through this hearing that evi- ntly there are many people in the engineering field in the country o feel that this is not an unsolvable problem, that it is possible over ong range to do something about the problem. Every group that s testified here so far has had some very fine suggestions and rec- mendations to make. You have made several in your fine tement.

I was particularly interested in one here about the fellowships t would produce highly trained teachers for high schools.

Dr. EMERSON. I think that is most important.

Representative PRICE. I think that is a very fine idea. I hope it ght be possible to work it out in some way.

Dr. EMERSON. I believe it will be most helpful because it is a uble-barreled thing. It helps the high schools. In 3 years it will gin to help the colleges. The colleges are terribly handicapped in taining new talent. They try to enlist a young man as an associate ofessor and maybe are able to pay him $7,000 or $8,000 a year and ey find that industry will take him in at a much higher rate of y than they are able to afford. But these men who have been ching for 3 years in high school, who have had 4 years of under- aduate work and 3 years of graduate work will be so thoroughly doctrinated in the academic atmosphere and the desire to teach at they will of their own volition be much more apt to go into ching.

Representative PRICE. I notice in your statement in talking about at your society is actually doing to try to help in this problem you l about going into high schools and providing experts on career idance in the schools and conferences with the parents and teachers. those contacts you must surely gather some information on the son more people are not going from high school into college engi- ering and scientific work. What sort of explanation do you get, what reaction do you get from the parents and teachers and some the students as to why they are not going into the engineering field?

Dr. EMERSON. Of course, the reasons are very varied. One bas reason is that it is difficult. They hear that half of the students wh enter engineering college do not graduate. In fact, it is only percent. Little Johnnie does not want to undertake a difficult thi when he can study ancient history and anthropology. Engineerin is hard and he may fail.

Representative PRICE. Somewhere along the line someone painte a very difficult picture to him instead of being a little more factu about it and doing a selling job to him rather than a discouraging jo

Dr. EMERSON. Part of this discouragement is due to the fact th he has made very low marks in algebra because he had a very po teacher in high school. He has not done very well in mathematics an his advisers tell him that mathematics is the foundation stone of eng neering education. These kids are pretty smart. They will say, " I made a D in algebra I doubt I could make the grade at Illinois St. Louis University," or wherever.

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Dr. EMERSON. Yes, sir. In the field of atomic energy, it does not very much good to have the ordinary qualified mechanical or electri- engineer. You need more than that. The colleges are now estab- hing programs to give a higher level of education in that particular ld. The men who deal with guided missiles, electronics, who deal th submarine detection, which I think is one of the most important lds, are those men who need advanced study to the level of a Ph. D. gree. Since the candidates for the Ph. D. degree are rigorously lected, it means that you get the most brilliant minds into those areas hich may do the United States the most good.

Last year in the engineering colleges there were only 599 Ph. D. grees granted. That is in all fields of engineering. That did not clude the scientists. There were 1,000 chemists, roughly 500 physi- ts, roughly 250 mathematicians who got Ph. D. degrees. They are very useful. In the whole United States there are only 40,000 ysicists and 4,000 of those have a Ph. D. degree. Of all the short- es that exist in the United States and the greatest need, regardless my interest in engineers, is in physicists.

Representative PRICE. Dr. Emerson, what branch of engineering is e majority of your membership?

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Mr. ROBBINS. The membership of the national society goes across e board including all the major branches and fields of employment. We have a little higher predominance of civil engineers than others though the majority of our membership is civil, electrical, and echanical.

Representative PRICE. Thank you very much, Dr. Emerson. We rtainly appreciate your cooperation and we are glad to have your e statement.

The next witness will be Dr. Henry Chauncey of the Educational esting Service.

Does your statement define the nature of your organization?

TATEMENT OF DR. HENRY CHAUNCEY, PRESIDENT, EDUCATIONAL TESTING SERVICE

Dr. CHAUNCEY. No.

My name is Henry Chauncey. I am the president of the Educa- onal Testing Service, which is a nonprofit organization aimed at nproving the guidance of students, the evaluation of their progress school, and when the time comes for them to move from one level education to another to improve the process of selection, through arious testing services and research in this area. The Educational esting Service is 8 years old. It was formed by the merger of the

Dr. EMERSON. Of course, the reasons are very varied. One bas reason is that it is difficult. They hear that half of the students wh enter engineering college do not graduate. In fact, it is only percent. Little Johnnie does not want to undertake a difficult thi when he can study ancient history and anthropology. Engineeri is hard and he may fail.

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three principal nonprofit testing agencies that existed prior to that time. It conducts a whole series of testing programs such as the college board admission testing programs, testing for admission to law schools, medical schools, actuarial tests, the Naval ROTC screening tests, Foreign Service examinations and a number of others. That is the general nature. Does that give the picture?

Representative PRICE. Thank you very much. The experience you have had in that work should contribute something to these hearings because that is one of the things we would like to know a bit about.

Dr. CHAUNCEY. It seems to me that it is definitely related and certainly my personal interests have been related to the particular problems to which these hearings are being devoted.

I appreciate very much the opportunity to give my views at this hearing. I might say I also appreciate the courteousness of the committee and the staff in the communications and the arrangements that have been made in connection with this testimony today.

Representative PRICE. We are pleased to have you as a witness, Doctor.

Dr. CHAUNCEY. In my testimony before this committee I am not going to try to discuss whether there is a current shortage of scientists or whether we are falling behind Russia in producing new scientists. This ground has already been well covered in publications which have appeared during the last few years by such men as Ivan London, John Turkevich, John Dunning, M. H. Trytten, Howard Meyerhoff, Eric Ashby, and William Benton, to give only a partial list.

I can say only that to my mind the problem is not whether we are in difficulty—because I am convinced we are— but what to do about it.

Mr. Chairman, I will not discuss the immediate problem of the utilization of scientists and engineers at the present time, but rather concern myself with the long-range problem which to me is more substantially important than even the immediate problem.

Basically, as best I can see, the trouble lies directly in our educational process today. In the first place, we do not have an adequate program for identifying our best minds early in their school careers so that we can give them the kind of training they should have. Secondly, we are not equipped, in most schools, to give them the thorough training they should have. Thirdly, we do not do a good job of imbuing young people in general and even very capable young people with the desire to study hard and prepare themselves for highly specialized scientific careers. And finally, we do not supply the financial help that many students must have—no matter how anxious and willing they may be—if they are to complete the long and arduous course of study that is required.

In other words, there are four important areas in which improvements need to be made: Identifying the ablest students, improving the quality of education, motivating students, and furnishing financial aid. I shall take up each of these four areas briefly in turn, with a view to considering how improvement can be brought about and who should be expected to take the responsibility for accomplishing it.

IDENTIFICATION

We lose out in the matter of identifying able students because we wait too long. We don't usually do anything very positive along these lines until the 11th or 12th grades. But able students should be caught

young—no later than the eighth or ninth grade—to make sure, first of all, that they don't drop out of school; secondly, that they take the kinds of courses that are necessary for college entrance; and thirdly, that they get full measure of value from the time they spend in the high school.

At present only 4 out of 5 students in the most able quarter of the population finish high school. Each year 60,000 students of high ability drop out of school before graduation. Early identification of the able students, if properly followed up by sound guidance, encouragement, and help, would certainly be an important factor in encouraging these 60,000 students to finish high school.

But just finishing high school, again, is not enough. The student must take the kinds of courses that are necessary for college entrance and I might add for particular major fields which he may wish to pursue in college, which include science and engineering, which have specific prerequisites. At present, only 2 out of 5 students in the top quarter on ability go on to college. Many students with high potential simply do not enroll in college preparatory programs. Early identification of the ablest students would be an important factor in increasing the number who do take the necessary precollege courses.

The best way to improve procedures for identifying superior students is to set up a statewide testing program in each State, beginning in the elementary school and continuing through high school. The program would include both achievement and aptitude tests which would either be administered to all students each year or to selected grades—e. g., 4th, 6th, 8th, 10th, et cetera. The test results would be extremely useful not only for spotting students of high ability but also for guiding the educational progress of all students.

They would also be invaluable for improving educational quality by showing in what respects students in a particular school or community were doing well, or poorly, as compared with students in other schools and communities elsewhere in the State. Moreover, because repeated testing provides a reliable cumulative record of the student's growth, the results from such a program would provide a much sounder basis for identifying high-ability people than would results from a "one-shot" testing program.

One of the merits of the educational system of the United States as compared to England and many foreign countries is that it is possible for students who find themselves late to shift into the academic program. In England at age 11 examinations are given which pretty well determine the student's future career, whether he will go on to the university or not. In this country there is opportunity to shift throughout the elementary and secondary school period. What we need is the evidence on which to encourage students to make such a shift. But the opportunity to do it is a very healthy thing, I think, in our educational system.

I might say that as a first step, since the program I have suggested here is a fairly large one, a testing program at the eighth or ninth grade level would be particularly important in identifying people who should be given guidance and encouragement to go to college. That is the critical time, because it is along about the ninth grade that students begin to have options in the courses they may take and may slip away from the academic program if they do not feel challenged to take the more difficult program.

The logical group to take the responsibility for conducting the testing program in each state would be the department of education or the State university in that State.

To some extent these groups already have testing programs, but most of them are at the 12th grade level, which, as I mentioned, is really too late.

IMPROVING EDUCATIONAL QUALITY

I now turn to the question of improving the quality of education. Even the college preparatory program, as carried on in most schools today, does not provide adequate training for our best students. Most of them do not get full measure of value from the time they spend in school. In some ways this is the fault of the curriculum itself, in some ways it is the fault of the teaching. For example, mathematics nowadays is taught so badly, as a rule, that many able students do poorly in it—frequently quite needlessly—or fail to take it at all beyond the required courses.

Representative PRICE. I think it has been established pretty well through the hearing by everyone who has testified on the subject that mathematics is just not taught very well in our secondary school system, when taught at all.

Dr. CHAUNCEY. Mr. Chairman, that is a subject on which it so happens that we have made a particular study at the request of and through a grant from the Carnegie Foundation recently. I brought a copy of this study with me which I would be glad to provide for the committee, if this is appropriate.

Representative PRICE. Would it be available to include in our report?

Dr. CHAUNCEY. It would be available to include by the time you issue a report. At the moment it has not been released. It will be released within a few weeks. There are a good many appendixes here. The introductory section, which summarizes it, would be of interest. The subject of this is "Survey of Mathematical Education, the Causes of Student Drop-Out, Failure and Incompetence at the Elementary and Secondary School Levels."

Representative PRICE. Would it be possible for you to give us a brief summary of what the report shows?

Dr. CHAUNCEY. It would be difficult for me to do that, I think. It is largely a matter of teaching on the one hand and of an antiquated curriculum on the other. There is at the present time a commission that is studying the curriculum of elementary and secondary school mathematics which when it presents its report will have the best thinking of the mathematicians of all levels on what the elementary and secondary school program should be like. I have a few comments on this in what follows in my statement.

Representative PRICE. That is fine. I would like to hear them.

Dr. CHAUNCY. In addition, the curriculum is out of date. It is quite feasible for a good student to complete 4 solid years of mathematics in high school, which in a modern program would include elements of plane, solid, and coordinate geometry, trigonometry, probability, statistics, and advanced algebra leading to an introduction to calculus. But very few do take 4 years of mathematics and even fewer take a modern program.

In other words, even in a good school, well-staffed and well-equipped, there is much room for improvement. Now take the smaller schools. To provide adequate mathematics training for the ablest students necessarily requires the availability of a full complement of mathematics courses. But only half the Nation's high schools have enrollments of 200 students or more. When all is said and done, how many schools with a total enrollment of less than 200 can reasonably be expected to give courses in the subjects mentioned above for the 3 or 4 students who are likely to benefit from it in a given year? It is not surprising, when the small size of so many high schools is considered, that only half the high schools in the country offer courses in chemistry, and less than half offer courses in physics. They can't afford to do so for a handful of students.

I think there has been some testimony given that these figures are misleading because they are based on statistics for 1 year. They overlook the fact that many schools offer physics and chemistry in alternate years. But even when allowance is made for this factor, there are one quarter of the schools in the country that do not offer physics and chemistry.

It would seem that for courses like these a small school, and even a larger one, should not be forced to depend on its own resources. The answer, to my mind, lies in taking advantage of technological developments, such as sound films and television. Research over the past 35 years indicates beyond any reasonable doubt that ordinary instructional films do a better teaching job than poor instructors and are at least as effective as the average instructor. Further, the findings show that the use of films serves to reduce instruction time considerably. It appears, also, that instruction by television is equivalent in effectiveness to instruction by sound films, and that any claims that can be made for the older medium will apply about equally well to the newer one.

It would seem to be quite feasible to prepare sound-film courses in various high school science and mathematics subjects, drawing on the best planning and teaching skills available, and the most able and ingenious people in the film industry. Still better, to provide a complete integrated course—making available to the schools not only the sound films but also the necessary textbooks, workbooks, lesson assignments, supplementary readings, laboratory experiment kits, and weekly and monthly tests.

This is the particular topic in my testimony that I feel most strongly about. I personally am thoroughly convinced that far better instruction could be made available to the youth of our country if we got the very best teachers in a particular field, let us say it is physics, together and planned carefully just what the course should cover, consider carefully just how the concepts and principles and the materials that were to be covered in a particular part of the course could best be presented, and whether the sound film is the ideal medium for this or whether it should come out of a textbook. In other words the course would be tried out with students and if certain films that had a particular purpose did not prove to be effective, they would be modified and changed and a new section of the course developed.

The development of the kind of complete instructional package that is needed to do the job right is an expensive proposition. To

insure the availability of the materials in the schools where they are most needed, the filmed courses would have to be distributed widely on a low-cost basis. This means that most of the initial production costs would have to be underwritten. Support for such a program might come from private foundations, industry, or from such groups as the National Science Foundation, and the Atomic Energy Commission.

This, it seems to me, is the opportunity to bring to education modern technological developments which have made us great in so many other ways but which we have not attempted to bring to bear on the educational process.

I think it is inevitable that we will ultimately come to something of this sort—some means of increasing the classroom teacher's productivity by making use of modern technology. There simply are not going to be enough trained people in the country to meet the needs of all fields for trained manpower and still continue to man the schools as we have done in the past.

The demands for trained manpower are increasing every day and even if we could lower the necessary numbers to the schools we would be holding some other segments of our society short of the trained manpower they need. The educational system which is virtually the same in its general framework and nature as it has been for a long period is, so far as modern progress is concerned, in the horse and buggy era.

Trying to do so is a losing battle. Sooner or later, I am convinced, we must come to the full use of sound films and television to carry on the regular instructional burden, with the teacher functioning as a planner and overseer of each student's progress. Under such an arrangement a teacher could function at a much higher level of skill than at present, take care of more students than at present, and earn more money than at present. And the general quality of education would be higher and the scope and flexibility of the program offered by each school would be much greater, with much more possibility of permitting students to progress at their own best pace, which is another important problem for the very able students. We have this lock-step system of education at the present time and able students get discouraged if they are not allowed to progress at the rate which they can easily progress at.

IMPROVING STUDENT MOTIVATION

In connection with the third area that needs improvement—student motivation toward higher education—it is sometimes hard for people who have grown up in certain kinds of homes, what we might call college-centered homes—to realize how little value many families place on a college education. The kind of climate in which it is taken for granted that the youngsters will go on to college is absent in many homes, where it is taken for granted, instead, that the boy will go to work to earn a living as soon as he has finished high school, or before.

To counteract this kind of thinking a program of careful guidance of students is essential, particularly throughout the upper elementary and high school levels. Such a program should be tied in very closely with the statewide testing program I outlined earlier. In fact, a thorough guidance program is absolutely essential if the test results

are to be used properly. By the same token, the testing is essential if the guidance program is to be worth anything.

Unfortunately, there is a severe shortage of trained guidance people. A recent survey by the United States Office of Education found that, out of 24,000 schools responding, only about 4,000 or 17 percent, had someone on the staff who devoted half time or more to guidance activities. In this kind of situation, it is necessary for the classroom teacher to contribute heavily to the guidance process. It is not easy for the overloaded teacher to do a good job under the circumstances, without help.

In an attempt to provide this kind of help, I might mention, that we are currently working on a series of Guidance Workbooks. These are intended to help the student, under the supervision of the homeroom teacher, pull together the kind of information he needs to gain some insight into his own abilities and interest, and to relate these to the requirements of various jobs and educational programs. But besides this teachers must make it a part of their responsibility to encourage able students to think in terms of going on to college.

They may even have to work with the parents of the able students who frequently are a deterring influence.

Better and more complete guidance in the schools will help. Increasing the prestige of high academic performance will help a great deal too.

This would tie in with the suggestion that Professor Rabi made.

Representative PRICE. What do you think of Dr. Rabi's suggestion?

Dr. CHAUNCEY. I think something of that nature would be very valuable.

Representative PRICE. He removes all possibility of discrimination. It is a wide free choice. No one is bound by any strings if they participate in the program. They are not forced into any particular pursuit. But it does open the avenue to the creation of a qualified pool from which to draw scientific and engineering students at the college level.

Dr. CHAUNCEY. With the decline of study in mathematics this is important and it is not only important for the physical sciences and natural sciences and engineering, but also for the social sciences, where mathematics is becoming more and more important. In fact, even for the average citizen's understanding of modern society and thinking sensibly about it, it is necessary to have somewhat better mathematics training than most students get at the present time. It seems to me that Professor Rabi's plan could be put in effect it would have a salutary influence.

Representative PRICE. Mathematics would not hurt any student regardless of what course he finally chose after he entered college.

Dr. CHAUNCEY. I agree, for mathematics, though not always necessary, is helpful in most fields of study. There are, of course, those who have a blind spot when it comes to mathematics, but under Professor Rabi's plan that would not be under compulsion to take advanced high-school mathematics, in any case.

It seems to me that a campaign put on by local service clubs in each community, publicizing the local students who stand highest each year in the statewide testing program mentioned earlier would help materially.

It would be worth while also to provide outstanding students and their parents with a special pamphlet describing job opportunities for trained people, the need for career planning, and the possibilities of financial aid if it is needed.

It is possible that sound films could be prepared which would be used by schools to encourage the college-going thinking of the able students.

FINANCIAL AID

The last area is the matter of financial aid. There are a great many scholarships available today awarded by colleges, industrial corporations, labor unions, social service clubs and other groups, but the total number is small when compared with the 200,000 students in the top quarter of their high-school classes who are not going on to college. The magnitude of the problem is such that a Federal scholarship program will be necessary. This might logically be administered by the United States Office of Education, the National Science Foundation, or the Atomic Energy Commission.

The present scholarship programs are skimming the cream of the cream. There is still a lot of good cream that just doesn't get the financial support to go to college.

I would like to point out that all four of these approaches—improving identification of talent, improving educational quality, improving motivation, and improving the financial picture—are interrelated. To tackle all four together is to accomplish much more than the sum of the separate parts, and to do so more economically.

Representative PRICE. I have just been thinking that Dr. Rabi's idea coordinated with your suggestion, that you feel eventually a Federal scholarship program will be necessary, what you have to try to avoid in the scholarship program, if it were Federal, would be discrimination. You would not do it for scientists and leave someone else.

Dr. CHAUNCEY. That is right.

Representative PRICE. Dr. Rabi's idea takes care of that objection to a Federal program. Why couldn't you carry it a step further and say that the groups with the high average in those tests would be awarded a scholarship, and let them choose their course.

Mr. CHAUNCEY. I would think that would certainly be possible.

Representative PRICE. It is merely my thinking on the subject. I am not proposing that.

Mr. CHAUNCEY. There is a clear and present need for more study of mathematics by students which seems to me justifies putting some premium on the study of mathematics, but at the same time following, as you suggested, the principle that one is not trying to divert people from one field to another, but merely giving them an opportunity to take as much mathematics as history and English and social studies, so they get equal exposure and an equal opportunity to make their decisions as to which field they wish to major in.

Representative PRICE. How far off is the release date on that report from the Carnegie Foundation?

Mr. CHAUNCEY. I am not quite sure. There is a shorter report that has been written for publication and it is at the printers now. The galley proofs will be back in a while. It is 2 or 3 weeks, I would think.

Representative PRICE. I wonder if it would be of any value to include the introductory part of the report in the record of this hearing? Would there be a material value to this committee?

Mr. CHAUNCEY. Yes; there would.

Representative PRICE. Would it be possible to include that in our record?

Mr. CHAUNCEY. How soon will your report be prepared?

Representative PRICE. I imagine it will be at least a month.

Mr. CHAUNCEY. Why not let me send you the final printed report which is an improved introduction, you might say, which would serve your purposes better.

Representative PRICE. I think that would take care of it. Without objection it will be included in the record of this hearing.

(The report referred to appears on pp. 345–364.)

Mr. CHAUNCEY. Improving the production of scientists and engineers is crucial to our well being whether or not we face the imminent prospect of a shooting war. In the long run our security rests on maintaining our technological supremacy, because on our technological supremacy depends both our standard of living and our military power.

Mr. Chairman, I added a few remarks as I came down on the train which I would like to have your permission to include with my testimony.

Representative PRICE. Very well.

Mr. CHAUNCEY. They are along the lines which you have been thinking, I am sure. In fact, I know it is so, because it is very close to what you have said in the letter which you wrote me.

As I see the situation, we have a battle on our hands. Enough news has come out of Russia so that we know what their educational system is doing, and the number of scientists and engineers they are producing and the way their economy is developing. We are engaged in a struggle for supremacy between two ways of life. Our way of life, we are convinced—we know—is superior. In America the individual leads a finer life. We believe in the dignity of and the worth of each individual, in his freedom of choice, and in his self-development. But we cannot protect and preserve our way of life merely by claiming its superiority or by demonstrating it. There is no impartial jury.

Faced with the aggressive Communist ideology we have two contests for which we have to prepare: Raising the standard of living of this country and of our allies and neutral nations and possible war. We cannot neglect either because the Russians have the choice of weapons, so to speak.

What does all this lead to? The limiting factor in our future growth is our trained manpower. The fullest development of our human resources is a must. We have the capability of doing a far better job than we have even done before, if we shake off the shackles of tradition and inertia. Unless we do, we will fail.

Have we the determination? Can we mobilize our efforts so that each of our youth gets the kind of education and training which will bring about his fullest development? This, to me, is the most crucial question that our country faces today.

Representative PRICE. Thank you very much, Dr. Chauncey. I think your statement was concise and very effective, particularly on the matter of identification. You told us what you find at the

secondary level. You made some suggestions which you think should be carried out to correct the problem that besets us. I think you have given the committee a very valuable statement and I am sure we will study it very thoroughly before we make a final report on these hearings.

Are there any questions? If not, thank you very much, Dr. Chauncey.

Mr. CHAUNCEY. Thank you very much, Mr. Chairman.

Representative PRICE. The next witness will be Dr. George E. Probst of the Edison Foundation. Dr. Probst, let me welcome you to the committee and express at the outset our appreciation for your taking the time to come before us and give us your thoughts and recommendations on this subject.

STATEMENT OF GEORGE E. PROBST, EXECUTIVE DIRECTOR OF THE THOMAS ALVA EDISON FOUNDATION

Mr. PROBST. Mr. Chairman, as executive director of the Thomas Alva Edison Foundation, I would like to convey to you our appreciation for the invitation, and also express the commendation of the Edison Foundation for your interest in this terrifyingly complex subject. Under the leadership of Mr. Charles Kettering, who is president of the Foundation, and Governor Charles Edison, who is honorary president of the Foundation, we have directed the program of the Foundation toward improving science education.

At the beginning I would like to bring several things to your attention that I think might prove to be of value for you and your committee.

Yesterday there came from the press of New York University the publication of the proceedings of the sixth Thomas Alva Edison Institute on The Growing Shortage of Scientists and Engineers. I think this will be of use to you, and I shall provide copies for all the members of your committee. I would like to bring this forward to you at this time.

Representative PRICE. We would be glad to have it.

Mr. PROBST. From this document we took two addresses, one by Rear Adm. Lewis L. Strauss, USNR, and one by Rear Adm. Hyman G. Rickover, USN. They occur in this pamphlet Freedom's Need for the Trained Man which I should like to bring to the attention of your committee members. We have distributed 18,000 of these pamphlets to educators, industrialists, school board trustees, and so forth.

Representative PRICE. Thank you very much, Mr. Probst. We are very glad to have those documents.

Mr. PROBST. You will find in the book I have given you addresses of Dr. Henry H. Armsby, Dr. Alan Waterman, Dr. Charles Kettering, and a number of people you have heard in the course of this hearing. I have been fortunate enough to hear a few of the distinguished authorities who have testified before this committee. I would very much agree with their view of the seriousness of the problem. I would like to say that this race for scientists that we are in with Russia and the whole problem of science education is undoubtedly the most complicated problem confronting any committee of Congress. I am sure that you are even more aware of it than I am. But it is worth saying, I think, that the Russians are collecting a harvest on the fruits of a

crash program that they have been pushing for 30 years. They are able to mobilize resources and devote their effort in a way so that students at a comparable age level to ours are being taught 40 percent more over the whole range of science education. This is done by them in a 6-day school week, a longer school year, and by concentration on science.

Over the whole range of American educational experience, as you have heard in these hearings, you see evidence of the deterioration of the American educational process. This has many causes. Unfortunately they all reinforce each other. It seems to me that this is what makes the problem so difficult. Further, we face a combined problem of shortage of both quality and numbers. It therefore becomes a situation in which people who are concerned with the problem easily fall into a quarrel with each other over what to emphasize—quality of engineering training, or a larger quantity of engineers. If I were asked what I would put emphasis on, I would say both quality and quantity of engineers are needed.

Representative PRICE. You have to have quantity in order to eventually get the quality you are looking for.

Mr. PROBST. Yes; the other thing about this whole problem—and here I repeat the view of Mr. Kettering—is that unfortunately human ability, temperament and the known factors of intelligence are not so fixed and predictable that we can pick out the people who are going to be the really brilliant scientists 20 years from now.

Representative PRICE. If you could do that, you would not worry about the problem.

Mr. PROBST. That is correct, sir.

Representative PRICE. You would not worry about the quantity at all if you knew you could pick the quality.

Mr. PROBST. That is right.

Representative VAN ZANDT. A moment ago you mentioned about the crash program of Russia.

Mr. PROBST. Yes.

Representative VAN ZANDT. What do you know about it?

Mr. PROBST. I am familiar with it from the publication of Mr. Nicholas DeWitt, from conversations and reading the work of Mr. John Turkevich, who undoubtedly is probably the best informed man in the country on this matter. Then I am acquainted with some of the people at the Harvard Russian Research Center such as Professor Alex Inkeles and Raymond Bauer who made a study of the Soviet professional training. The Russians have been working at this a long time. They should not be in any way underestimated. The Russions are training intensively about three times as many scientists as we are.

Representative VAN ZANDT. You said it has been in operation for 30 years?

Mr. PROBST. Yes; the thing that I want to mention in speaking of this problem of quality, reflecting the viewpoint of Mr. Kettering, is that our Foundation is one which favors an effort and program that will stimulate every boy and girl and give him a chance to become acquainted with the things of science and to become actively interested in science, during the ages of about 8 to 15.

Representative PRICE. That is how you develop quality.

Mr. PROBST. Yes; from that large group there can then appear the people who are able to make a prominent and significant contribution. And we should encourage them to do so; if they are interested in science. One is always forced to revert to personal experience. I think of the case of my brother, who did not do very well through high school in California. He got C's and finally was given a battery of tests and told that he should not go to college, and that his aptitude was in the direction of owning and running a filling station. He struggled on through and finally graduated from the University of California Engineering School.

At the present time, he is doing research on corrosion for the Shell Oil Co., and has a number of patents to his name, and is regarded as one of the leading people in the field. But one of the best counselors I ever saw in the educational system, Dr. Lounsbury, gave him the authoritative verdict that he should not make the try.

The fact that he had straight A's in his last year in engineering is a further irony in the situation.

I cite this simply as one of many illustrations that can be assembled about the problem and difficulties we face if we try to decide in advance when you are looking at young boys and girls in high school which one of these people is going to show the kind of special talent we need.

Related to this problem, I find myself in the position of looking forward to a question I know you are going to ask. That is, what do I think of Dr. I. Rabi's suggestion of giving a prize to high-school graduates who achieve a command of mathematics. I was present when he made his very interesting suggestion. I thought a good deal about what I would say if I were asked, and have found it more and more difficult to suggest briefly why it has seemed to me that his suggestion raises some serious difficulties—which have not been mentioned yet by other witnesses who have testified.

I thought that Gen. David Sarnoff was on the right track this morning when he pointed out that the plan needed amplification and that the prize should be given for knowledge of physics and chemistry, and more than mathematics. There seems to be some evidence that one of the reasons some of the boys do not go into engineering is because they do not have mathematical talent. Mathematics is one of the 17 factors of intelligence according to L. L. Thurston. It is only one. There is a great deal of engineering and science that is not mathematics.

Mr. Kettering's story is that he gave the MIT entrance examination to his 57 top paid engineers in General Motors, and only 4 of them passed. These are among the highest quality engineers in the business. I would certainly agree that there are areas in science and engineering where mathematics is absolutely crucial. Dr. Rabi works in an important part of that area. There are other areas where a great deal is done by people of imagination and intuition working with things and materials.

Here their engineering activity is not centrally mathematics.

It may be true as a hypothesis that one of the reasons why we have a decline in the number of students going into science in this country is because industry siphoned out the chemistry and physics teachers who are most useful. What we have left is mathematics teachers who do not always teach too well.

As a result, the only experience a high school student has with science is mathematics. Having that as his only sample, he concludes that science and engineering *is* mathematics. He finds mathematics difficult and decides there are other places to work in our society where the economic rewards are just as high or higher. He chooses some other occupation rather than trying further in engineering—something which he may have the talent for

You understand I am not arguing against the importance of mathematics. I am just suggesting that I think the effect of these proposed prizes given only in mathematics might encourage school boards to emphasize the teaching of mathematics and continue the neglect of the teaching of physics and chemistry.

Representative PRICE. I think Dr. Rabi's idea of limited mathematics was to make that more inclusive than if you went to other subjects like physics and chemistry. You would begin to eliminate. We wanted it more inclusive in order to make it less discriminatory.

Mr. PROBST. I respect the Dr. Rabi highly. He is one of the outstanding men in the country. I merely bring to the committee's attention a possible consequence of the adoption of this proposal to give prizes for mathematics. It might have an adverse effect on the amount of physics and chemistry offered and studied in the high schools.

Representative PRICE. That was the quick reaction of General Sarnoff.

Mr. PROBST. Yes. I would like to turn from some of these brief comments to say further that I endorse the testimony of Dr. Harry C. Kelly, and express the confidence that I have (and other people in the Edison Foundation who are associated with it) in the contribution that the National Science Foundation is making. We think the National Science Foundation approach of having a series of very admirable experimental pilot programs for postdoctorate fellowships, mathematics teachers, the visiting scientist program, special joint projects to alleviate teaching shortages, the support of the Science Clubs of America (which I think should be enlarged), and many other forward-looking successful projects, are the kinds of pilot projects that have to be done on many fronts.

What I would hope is that the committee and Congress would strengthen the support that is given to the National Science Foundation.

A further development which I view with considerable enthusiasm is the formation and appointment on April 3 of the National Committee on the Development of Scientists and Engineers, whose membership offers a promising diversity of background and experience. This National Committee will draw on the National Science Foundation staff, and I am sure they are going to do very valuable work. I am delighted that they are not on a terminal appointment to go out of business in 2 years, as many committees are.

I should also like to say that the Edison Foundation has offered an invitation to them to participate in a conference on the supply and requirements for scientists which we hope that the members of this new National Committee will accept.

Some of the projects which the Edison Foundation is carrying on may be of interest to the subcommittee. With the New York University Press, in addition to this book I have just given you, we are

also publishing a study of the enrollment situation in the 19 fields of engineering. This study is being edited by Dr. Norman Barish, professor of the New York University College of Engineering, and is being written by different experts in the different fields of engineering. With the evidence of enrollment in the 19 fields during the past 10 years, and what the prospective need is, it will be a definitive and helpful volume for high school counselors to young people as to what careers in science they might enter.

We are also encouraging the production of quality materials in the mass media designed to stimulate curiosity in science on the part of boys and girls.

I should like to say, further, that we are very much in agreement with the views of Admiral Rickover as to the seriousness of the problem and agree with him that everyone, in whatever position of authority and responsibility he occupies, should make an effort to approach the science education problem without waiting for someone else to solve it. I think that his program of training his own men, his advocacy of special schools for training and his efforts to create interest in the development of a school curriculum that would include more days of the year are to be highly commended. I greatly admire his work in behalf of science education.

I would like also to bring to the attention of the committee the summary and conclusions of the 150 participants in the Edison Fifth Institute on this same problem. Rather than read the summary, and rather than bringing to your attention at this moment the specific steps for immediate action recommended by this conference in the field of industry, professional societies, Federal agenceis, what State departments and local boards of education could do, I would like to file this with your staff. I refer to pages 30 to 33 in the Fifth Edison Institute Report.

Representative PRICE. That may be done.

Mr. PROBST. I would like to describe the Edison Foundation efforts in a field that matters a good deal in affecting the decisions of young people about their careers and affecting their interest in education.

In the search for possible ways to attract our boys and girls to the sciences and engineering, and to make the public aware of the serious implications of the current shortage, surprisingly little thought has been given to what the mass media might do. Many millions of child-hours are spent Monday through Sunday by United States youngsters on television, movies, radio, and comic books. It is currently fashionable to say that the mass media—not the classrooms—are the true schools of youth today. These media condition our children, developing their values, affecting their tastes, and influencing the kind of heroes they will admire and the professions they will respect.

Have the mass media made serious efforts to make careers in science and engineering seem desirable and worthwhile to America's boys and girls?

The Edison Foundation has had an unusual opportunity to evaluate the role the mass media fill in this area. Last year on May 4 we began a program of Edison Foundation National Mass Media Awards to encourage more wholesome influences for youth in the mass media.

The awards program is the first attempt to combine the efforts of 62 national organizations to influence 5 branches of the mass media—

films, television, radio, children's books, and comic books—and to give recognition to works that (1) interest young people in science and engineering; (2) contribute to the growth and development of children, and serve as a source of inspiration and guidance to them; and (3) make the ideals and values of the American tradition meaningful to the Nation's youth. These Edison awards have attracted a great deal of national attention.

I would like to pause for a moment at this point to emphasize that we give our awards to mass media science materials that are aimed at younger children, and to explain why we do this.

It has been ascertained that unless children become interested in nature and in the sciences before they reach high school, they are probably lost to these disciplines. It is most unlikely that they will develop a scientific bent later on. That is why we have concentrated on calling attention to, and encouraging more, science productions aimed at children from 8 to 14 years of age.

Our committees on recommendations are composed of persons who are respected as authorities in their respective fields. Last year, these committees evaluated all the available materials in making their nominations in each award category. The decision of the winner is made by vote of participating representatives of the national organizations.

In only one of the five fields in which we presented awards did a recommendations committee find that a good job was being done to make science seem attractive and important to American youngsters. This was in the field of children's books, where, I am happy to say, the committee encountered an embarrassment of riches. There were so many fine science books for children that it was difficult to make a choice; 98 children's books of the 1,485 children's books published in 1955, were considered by us for awards at the request of 41 publishers and our committee members. Of these, 30 books were in the juvenile science field.

One editor of juvenile books has told me that as a result of the establishment of these Edison awards, the realization of the need for good science books for children is causing this publisher to increase the number of science books her company published.

But, for the most part, the problem in this field is not scarcity of good material, but rather a clear need for attracting the attention of parents and children to the good juvenile science books which already exist. The publications of these 62 national organizations are cooperating in doing this. The Edison award is the first award that has ever been given for "the best children's science book" in the United States.

Compared to the coverage of broadcasting media, comic books and films, books reach a relatively small segment of our young population. But books are of very great importance in the development of scientists and engineers. Edison was famous as an omnivorous reader as a boy, and the life story of almost all creative scientists shows the importance of books in their experience. This is one of the reasons I am so much in favor of the National Science Foundation program of the traveling library of books for high schools that do not have adequate library facilities.

I must report that in the other four branches of the mass media—films, television, radio, and comic books—our committee of experts found very little material in science.

On network radio, there is but one science program. Fortunately, it is on a level to be understood by children. It is called Science Adventures, and it has the virtue of trying to explain scientific phenomena in everyday language.

On television, offerings are just as scarce. There are two science programs for children, but only one of them is devoted to the physical sciences. This is "Mr. Wizard," an National Broadcasting Co. program which tries to start right at home and translate the everyday things of life into meaningful terms of matter and energy. Even better, the program is directed at children of 7 to 14 years of age and interests them in doing experiments at home. The other program, Adventure, produced in cooperation with the Museum of Natural History by CBS, is a series featuring natural science. But aside from "Mr. Wizard" and Adventure on television, and Science Adventures on radio, there is no systematic, intensive effort to arouse the interests of boys and girls in science, start them doing experiments at home, and perhaps kindle the spark that will set another Bell or Edison on his way.

Last year, 1955, there was not a single 35-millimeter science film devoted to the wonders of scientific discovery released for showing before our 90 million theater patrons. When we consider that Edison's invention of the motion picture was conceived with hope that its use might inform and inspire the American people, we may better understand how we are neglecting the chance to show the lives of Benjamin Franklin, Eli Whitney, Orville Wright, and Jonas Salk.

In the field of comic books, we also found a shortage of real science comics, but the response of the publishers has been encouraging.

Currently, comic-book circulation is between 70 to 100 million copies a month. There are approximately 35 million boys and girls between 5 and 17 years of age. This is an average of 2 to 3 comic books a month for each youngster.

As a matter of fact, the picture-strip technique of the comic offers wonderful possibilities for presenting science education in an entertaining form. It is admirably suited for teaching young children, who have trouble reading difficult material. Highly successful use of comics for educational purposes has been made, as you know, by the armed services, by the New York State Mental Hygiene Department, and by industries such as General Motors, General Electric, and so on.

Many representatives of 62 national organizations that have participated in the Edison mass media national awards program have been amazed by the dearth of programs in the mass media that would have the effect of interesting boys and girls in careers of science and engineering. Many committee members expressed the belief that the leaders of the mass media probably did not realize the extent of their neglect of this field, nor realize what could be done to improve the situation. At the Edison Foundation's National Conference on Youth, held on May 4, 1955, considerable attention was given to the problem of how the mass media could go about the task of accomplishing popular and useful programs in science.

Vice President Nixon, Mr. Kettering, Rear Adm. Frederick R. Furth, United States Navy, and others spoke. I should like to quote from one of the speakers at this meeting, Dr. Martha M. Eliot, Chief of the United States Children's Bureau, who gave this advice on how to motivate our boys and girls:

> My specific suggestion then, to you * * * who are searching for more recruits for the sciences, is to give children more heroes.
>
> Give them more heroes, and fewer villains, on whom they can pattern their lives. Encourage them to identify with persons, imaginary or real, whom they can admire and love. Let us be done with extolling characters who are simply smarter, more cagey, or more crafty than the next one.

We have been hearing much about the success the Soviets have had in directing so many of their young people to careers in science and engineering.

How have the Soviets achieved this?

One answer was presented by Chancellor Eric Ashby of Queens University, Belfast, a man who spent many years in Russia as scientific attaché to the Australian Legation. Recently he wrote that the Soviets do more than merely issue orders and then proceed to build schools and technical institutes, and to conscript teachers. They do these things, but they also guide and inspire Soviet children across one-sixth of the globe, he said, toward vocations useful to the state—such as science and engineering. Books written for children boost the status of scientists. Their heroes are not spies and saboteurs, but engineers and scientists. Instead of any vaudeville concept of absent-minded professors missing a few buttons, these Soviet children see images of scientists and engineers accomplishing daring adventures, measuring the salinity of water under icebergs at the North Pole, diverting the courses of rivers to irrigate deserts, and hunting uranium.

Surely we can solve the shortage of trained scientific manpower in an acceptable American way. There is room in a democratic country for the mass media voluntarily to orient children toward the sciences and engineering.

What might the situation have been today if, over the years, some of the time devoted to Westerns and detective stories had been used voluntarily by the media for gaining respect and admiration for scientists and for pointing up the fun and excitement of scientific investigation and experiment?

Our mass media have an unparalleled opportunity to develop stories for children in which scientists and inventors are the heroes. There is so much drama, excitement, and adventure in scientific discovery, that it is surprising the media have overlooked this source of material to exploit for our purpose.

We need to do this so as to create a climate in which the youth of today no longer feel it is a stigma to be a brain.

Moreover, both on television and in films, it should be possible to present the achievements of scientists in such a way that young viewers would be stimulated to do experiments and to want to know more about the world they live in.

There are, of course, serious obstacles to presenting scientific materials in entertaining form. Some sponsors and professional media people have an idea that educational science programs must inevitably be dull, difficult to understand, and incapable of holding large audiences.

We are told that there is a real prejudice against science and a lack of respect for scientists. For instance, Dr. Melvin Barnes, assistant superintendent of the Oklahoma City schools, asked 100 high-school students why high-school students did not take elective advanced math and science courses. The youngsters' replies expressed stereotypes of scientists as squares, as long hairs, as little old men with beards working in musty laboratories. Some believed that it cost too much money to get a scientific education, considering the financial returns, and that science and math courses were dull, difficult, took too much of their school time.

But whatever we have failed to do in the past, we can do in the present and in the future. Opportunities have been neglected by and through the mass media thus far. This neglect appears to me to be a contributing factor to the lack of interest and respect on the part of our youth for scientific careers. The opportunities are still here. We can remedy the situation. The mass media want to serve their audience. We want to help make it good business as well as fine public service for them to do so.

We appreciate that work with the mass media is only one part of a broad panorama. I have stressed it here because I think probably I would be the only witness to take this matter up in detail. The influence, in addition to the mass media item, of the thousands of school boards in improving curriculum, the lively research and discussion being devoted to the problems of science education, the interested cooperation of industry in the educational process and a dozen other factors all have their roles to play. Disputes over the respective values of various programs is irrelevant. We need both quantity and quality. There is an enormous vacuum to be filled.

May I suggest the following needs for your consideration:

1. One basic problem is that there should be sufficient financial rewards to attract good scientists and good science teachers. That is a problem complicated by the circumstance that 57,000 school boards have individual autonomy within the framework of State-aid grants. Compared with Soviet Russia, we have a Balkanized educational situation. Good teaching makes the study of the world around us fascinating. Bad teachers detour good students away from careers in the sciences and every other exacting specialized field.

2. Through the mass media we must emphasize the importance of science and engineering to national survival and peacetime progress. The current stereotype of the scientist as eccentric or evil can be rectified through intelligent self-discipline on the part of broadcast producers and publishers. They have more valid material if they recognize scientists as people making genuine and important contributions.

3. Every American has a stake in getting larger support for the excellent programs of the National Science Foundation.

Thank you.

Representative PRICE. Mr. Probst, may I say at this morning's session of the committee when General Sarnoff appeared as a witness, the subject of dramatizing the work of scientists through the mass media of television and radio was brought up.

Mr. PROBST. Yes.

Representative PRICE. I have a sincere hope that perhaps the very discussion of that this morning may lead to a stimulus of such presentations.

Mr. PROBST. I was delighted that you made that point to General Sarnoff, Mr. Chairman. I thought it was a very fine thing that you did in raising that matter. There are so many things that might be done if you could get the broadcasting officials and mass media interested.

For example, one of the things which we all see is the weekly 10 pages of advertisements in the New York Times in which companies compete for engineers. If you know the New York Times space rates, annually this represents an expenditure of about $4 million to advertise for engineers. You could do a great deal with $4 million in establishing one of Admiral Rickover's schools for training young scientists, or doing something with the science clubs and science fairs to interest American youngsters in science. I really think that industry needs some suggestions and some leadership in this regard, that your committee might give.

I think General Sarnoff was correct in saying that if the Federal Government moves out and says that what we need to do is so and so, industry would follow and would cooperate. Industry is spending so much money in this field recruiting men and not getting them.

Representative PRICE. We are hoping that at the conclusion of these hearings industry and educational systems throughout the country will avail themselves of the opportunity to read the testimony that has been presented here during the past 2 weeks. I think that if they do read it, they will find many helpful suggestions on this problem.

You have given many here this afternoon, as has Dr. Chauncey before you. Almost every witness before this committee had some definite recommendation to make. They all had merit. If some of the suggestions were followed, I am certain that this problem could be solved within a reasonable length of time.

Mr. PROBST. Yes. I would agree with you, Mr. Chairman. It is going to take quite a long time and everybody has to keep at it. None of the committees should go out of date.

Representative PRICE. We appreciate that fact. I have never in my experience here in Congress seen so many definite suggestions and recommendations made on a subject as I have seen on this particular subject, since we have started these hearings. There has not been a witness so far who had not had an idea and had a suggestion. All of them certainly had some degree of merit to them.

Mr. Van Zandt, have you any questions?

Representative VAN ZANDT. No, thank you.

Representative PRICE. Thank you, Mr. Probst. We certainly appreciate your fine statement and your cooperation.

Mr. PROBST. I want to congratulate the committee in going into this in the way you are doing it.

Representative PRICE. Thank you.

Mr. PROBST. Thank you very much.

Representative PRICE. The next witness will be Dr. John Turkevich, of Princeton University.

Do you have a prepared statement, or would you just like to make an oral statement before the committee?

STATEMENT OF DR. JOHN TURKEVICH, EUGENE HIGGINS RESEARCH PROFESSOR OF CHEMISTRY, PRINCETON UNIVERSITY

Dr. TURKEVICH. I would like to make an oral statement before the committee, if I may, Mr. Chairman.

Representative PRICE. Would you identify yourself a little better than I have been able to, Doctor? I just identified you as a professor from Princeton University. Is there any other identification you would like to have on the record?

Dr. TURKEVICH. I am the Eugene Higgins research professor of chemistry at Princeton University. I have taught at Princeton for 20 years. One of my main courses is the general course in chemistry involving 300 people. I think I have taught more Princeton undergraduates than any other member.

I have also been associated with the atomic energy enterprise before the Manhattan project started. We initiated some of the heavy-water work at Princeton in connection with the Canadian Government.

I have been a consultant to the Atomic Energy Commission ever since its formation. I have been associated with the Brookhaven National Laboratory. I also have given a course in the last 2 years at the Woodrow Wilson School of International Affairs at Princeton on the relation of government and science.

I have also spent a little of my spare time dabbling in some of the aspects of Soviet science. My wife and I published for about 6 years a journal under the auspices of the Atomic Energy Commission, and published at the Brookhaven National Laboratory, called the Guide to Russian Scientific Periodic Literature. This was discontinued for a certain amount of time, but I have still continued my interest in Russian affairs, Russian science affairs.

I was a member of the United States delegation to the Geneva Conference on the Peaceful Uses of Atomic Energy.

I think I have said enough.

Representative PRICE. Thank you, Doctor. Will you proceed with whatever statement you desire to make to the committee?

Dr. TURKEVICH. As both an educator and as a student of Soviet science, I would like to present a certain point of view—a long-range point of view—that I have been able to pick up in my studies. I will not dwell on the details, but I will take advantage of my prerogative of a university professor of taking the long-range point of view.

I think if we squeeze through the next 10 years, humanity will approach a millenium. Wars will be suicidal and will disappear. As the evidence piled up at the Geneva Conference on the Peaceful Uses of Atomic Energy, shows, there will be enough energy for every country to satisfy their justified aims and guarantee a steady development of standard of living, giving another necessary condition for peace and prosperity of humanity.

It is my evidence, and I have received evidence from my contacts with Russian scientists and Soviet scientific literature, that this point of view may be shared by some of the people in the Soviet Union. We definitely cannot bank on that. We have to keep our stockpile up and our guard up. But there is this hopeful thing in the present world situation.

This does not mean that we are not going to have competition with the Soviet Union. What this means to my mind is that competition

is going to go from military fields into economic, political, cultural, scientific, and technological fields, and I hope with time even into the spiritual field. We have seen evidence of that in Geneva.

I would like to bring to your attention an incident that occurred to me I think is very revealing of the mentality of some of the higher Soviet officials. I gave a talk on the use of isotopes in chemistry at one of the last sessions at the Geneva Conference, and after the session one of the top Soviet officials came up to me and congratulated me on my presentation and my work. I answered him in the following way: I said that I was very happy to see competition between our two countries in scientific and cultural fields rather than in military fields. I know Russian. I spoke Russian with him fluently. I used the word for competition called "concurencia." The Russian shook his head and said "Turkevich, don't use that word. That word has bad connotations in Moscow. Concurencia means getting ahead by pushing the rival into the ground. We have another expression called "sorevnovange," which means getting ahead by climbing on his shoulders.

This, Mr. Chairman, I think reveals the attitude of the top echelons of Soviet scientists. They are not out to destroy us as they were before. They are out to build on top of us. I think you can see that in their general plan of coexistence.

I think you will see—and this is my prediction, provided we can keep the weapon aspect under control—more and more competition for the minds of the neutrals on the part of the Soviet Government. It is for this reason that science and technology looms very big in the Soviet thinking.

I think I ought to mention to you some of the points that have not been revealed in the testimony that I have seen before it was presented to your committee, to show just what the implementation is of this Russian ideal. Because they believe—and I have talked with enough of them to be convinced—that they have a way of life. Their approach is very mature to our mind. I am convinced, and I think we are all convinced, that we are the bearers of the proper traditions of human life, but we will have to fight for it. The Russian strength expresses itself in science in a number of things.

The manpower problem is your specific target and has been discussed. There are two phases to the Soviet manpower problem. One is the big bulk of engineers and scientists. They are certainly turning out a large number of them, and I will not cite the figures here. I have published them. Mr. DeWitt has made a very excellent study of them.

I would like to comment on some of those figures. The Soviet Union needs more engineers than we do. Frankly, I find a little silver lining in that cloud. A thing that has not been pointed out before, but I think a real thing in their manpower situation, is the following: We, in the United States, are being faced with a war baby bulge. Our educators are screaming that we are going to have too many students, we will not have enough room for them. This is creating problems in our educational system.

On the other hand, the Soviet Union has a war baby sag, a terrific sag in their population profile. This sag amounts to 8 million people who were not born during the war years. You have to remember that two-thirds of the population of the Soviet Union was under

enemy control during the war years. The country was in a state of shock. My expert friends on demography tell me that sterility is very high in state of shock. The result is that if you look at the population profile there is a certain heartening thing in this picture. I would not bank on it, but it is there. In the classes attended by the 12-year-olds, 11-year-olds, there is a tremendous drop in numbers. I was told by a friend that some classes of 12-year-olds where normally they would have 40 students they only have 4 or 5. This may be one reason why the Soviets are giving this big push. They can see this coming up. They are going to have a manpower shortage.

This does not mean that we just rest on our oars, and do not look into this problem of shortage on our side. There it is, there I think your committee ought to know about it and look into it.

The other aspect of the manpower situation that I would like to present to you, if I may——

Representative VAN ZANDT. May I ask a few questions at this point?

Mr. TURKEVICH. Yes; I would be very happy if you would.

Representative VAN ZANDT. I would like to go back to the point you made about getting ahead by "climbing on his shoulders." Are you of the opinion that the Russians have the same ability and leadership as we have?

Dr. TURKEVICH. You mean their building on our shoulders.

Representative VAN ZANDT. I mean do they have the ability that we have before they start to build?

Dr. TURKEVICH. Let me put it this way. In science you run into this problem, that leadership is expensive for the following reason you put yourself into a position of a research director, as I have been on a number of occasions, you have a team of people you are driving. You don't know what you are going to get in research. You are hoping you are going to realize a success. You just have to drive them sufficiently so that they don't get sore at you and leave and try to get the maximum out of them, particularly if you are working on a crash program.

On the other hand, if you have the assurance that this can be done, which a country that is following has—because it knows that the leader is able to do it, then the second person can do it—then this is a terrific asset.

I happen to subscribe to the point of view that neither I nor my country is going to be in the position of following. We have to pay for the leadership. We have been paying for this leadership. A followup job is a much cheaper job, it requires less brains, less imagination. That is where they are right now. That is why they are making such prograss and catching up to us.

Representative VAN ZANDT. Do you have any knowledge of the kind of engineers they have?

Dr. TURKEVICH. I am not in a position to know in detail the numbers of people in a particular engineering group. I am not in a position to tell you how good individuals are. This is a statistical thing. I have taught a lot of engineers in this country at Princeton. Those that we saw at Geneva and at the delegations here undoubtedly represent their best. But I must say this, and I would like to make this a part of the record, that their textbooks, their curriculum are excellent. They are certainly satisfactory. After you have given a man a fun-

damental training in engineering, where he knows his basic art, it is up to the man. It is up to the motivation. It is up to the social setting that he is in as to what he will do. Even we at Princeton will subscribe to the fact that other engineering schools produce better engineers at times than we do at Princeton.

Representative VAN ZANDT. The next question, Doctor, concerns your statement that they need more engineers. Why?

Dr. TURKEVICH. They are in an expanding economy from the technological point of view. Many of our industries are sufficiently expanded and expansion is tailing off. They have made a mistake in their program, and this has been conceded by some of their leaders, in that they have been too specialized. This is the advantage of our liberal arts approach, of our type of living, where a man is not a cog in a machine, but can be adapted from one engineering type of work to another.

Representative VAN ZANDT. When did this real effort on their part begin over there? Has it been going on for years and years, or has it recently started?

Dr. TURKEVICH. We can take the date of recognition of science as being important from 1919. Lenin wrote a very famous letter saying that the only hope for the Soviet Union to get into communism is to use advanced technology. It is part of their Marxist creed that it is very important to control the instruments of production.

Representative VAN ZANDT. How long did it take them to get their program put together?

Dr. TURKEVICH. Their program took several tailspins. Remember, anything that takes place in the Soviet Union goes through all sorts of contortions. They had first an attempt to create a science and technological personnel completely from the proletariat and the peasants. This failed. Then they used their own experts and during the numerous purges that took place in the Soviet Union, they have always been suspect because of their western learnings. The Lysensko business, the placing of ideology by the Central Communist Party on science undoubtedly hampered the development of science. But they have always had, or they have for the last 15 to 20 years cried, "Let us build up our cadres. Let us build up our manpower."

I would like to make one or two points so as not to keep you gentlemen too busy too long.

The other point I want to make on manpower is the rise, to my mind, of the leadership class in science and technology. To us educators in science, who are interested in Soviet affairs, it is a very interesting problem as to whether the Soviet state could develop the intellectual leadership that was characterized by imperial Russia. We had our doubts whether it could be developed from the proletariat. Whether one can bridge the culture gap in one generation, in other words.

I think our doubts have been justified. Soviet leadership right now comes from the old Russian intelligentsia, the same group that at the end of the 19th and beginning of the 20th century produced Tchaikovsky, Chekov. The same group is back there running Soviet science and technology. They are highly cultured people. They are very effective leaders. There are not too many of them. They are well off. Almost invariably their children go into the scientific field.

In science, having a large pool of men is not sufficient. In science, more than anything else, and particularly in science that is going to

lead the world, one has to have leadership and very high grade leadership. Our country has been very fortunate in this respect.

This very interesting situation—that leadership in Soviet science comes from the old Russian intelligentsia, it should be a matter of some concern to us.

Representative PRICE. Doctor, on that point, I would not like to get ourselves in the position that because the main requisite is quality and leadership that we should not strive for quantity, too, because you are more apt to get that leadership and the quality if you have more participants in a program. Is that not correct?

Dr. TURKEVICH. That is correct, and I would subscribe to that.

Representative PRICE. I would not want to get the feeling abroad that all we are thinking about is numbers. That is not what we are thinking of.

Dr. TURKEVICH. I know you are not.

Representative PRICE. We are thinking of numbers only because the more you have the more apt you are to find the really great mind.

Dr. TURKEVICH. The only reason, Mr. Chairman, I am emphasizing this point is to underline the gravity of the situation in the Soviet Union; that this mass that is being produced also has some very intelligent leadership.

Representative PRICE. My fear is that some time when we stress the quality thing, the average person will get the idea here are these Congressmen sitting up there and talking about producing scientists without regard to quality. If you had one good man he would make up for 100 other scientists. I want to dispel the idea that we think only of quantity and of numbers.

Dr. TURKEVICH. I certainly subscribe to your point of view. There are a number of other items that might be mentioned in evaluating and assessing the Soviet scientific and technological strength, the character of their educational system. The evidence has been presented to you undoubtedly on that phase of the Soviet manpower problem. I would just like to mention the fact that their training tends to be too specialized. Also, the gravity of their narrow educational system in that by giving them only scientific and technological training, the Soviet engineer and scientist is not politically, culturally, and economically as mature as our man is.

I have been asked the question, shall we completely go over to the Soviet system and stress more science and technology or stress science and technology exclusively, and I would not subscribe to that, because the end result would be that we would be like them, and we certainly don't want to be that. We have a wonderful system in this country. It has gotten rusty in a place or two, and it has to be fixed up. But we should not, under any condition, try to make an exclusively scientific and technological program for our youth.

The other point I would like to make is that their science is highly organized. Their scientific and technological part of the state is as organized as their army is, as its general staff. It has its elite corps. It has its cleanup, suicide boys. They are very well equipped. Most of the equipment seems to be of recent Soviet manufacture. They have a very wide publication program to make sure that their men are aware of all the developments taking place in foreign countries.

Representative PRICE. Are there publications available to our scientists and engineers?

Dr. TURKEVICH. Most of them are. I have seen quite a few of them. There is a tremendous number of them coming into this counrty. The sad thing is that because of the language barrier and because there is no efficient way of bridging that barrier, it is not available to the general public.

Representative PRICE. It is much easier for them to follow what we are doing than it is for us to follow what they are doing. The language barrier is in their favor.

Dr. TURKEVICH. To give you an idea on that, Mr. Chairman, it is my understanding that in Moscow they have some secondary schools where all instruction to the children of the elite in Soviet society is given in English.

Representative PRICE. I understand that they are required to take about 7 years of English in their school system.

Dr. TURKEVICH. It is even more than that for this elite group. You are quite correct, Mr. Chairman. But in addition to that, the children of their top scientists get all their education in English. As I have once remarked they even learn French in English.

Representative VAN ZANDT. I have a question at that point, Doctor. How many of the Russian delegation at Geneva spoke English?

Dr. TURKEVICH. Very few, but very many understood it.

Representative VAN ZANDT. They understood but could not speak it?

Dr. TURKEVICH. Yes.

Representative VAN ZANDT. We were told there by several people that the average youngster had 7 years of English. I said to myself several times, here are a group of scientists and only a few of them can speak English, although I understood the majority could understand it.

Dr. TURKEVICH. You may know that it takes practice and they are exploiting it. I have met several and with every new meeting their English is better and better. In addition to this, some of the seminars, I understand, in physics are conducted in English so as to give their young scientists practice in presenting scientific material in English.

Representative PRICE. Doctor, I think we have in our study that when this western group of scientists visited Moscow, they were amazed to find that nothing but English was spoken in the laboratories over there, and all their publications in their laboratories at that time were in English.

Dr. TURKEVICH. Their foreign contacts are very important. I think the new look that Soviet science has, this look reflecting itself in permission for Soviet scientists to visit laboratories in France and England, and also the fact that Marxism is disappearing very rapidly from their thinking—and Marxism certainly was a handicap to efficient scientific work—increases the threat that Soviet science is going to offer. We are going to have a good, good contest on our hands. Some of this threat, as you know, or some of this potential, has been translated into actual weapons and scientific and technological achievements. But I think as time goes on they are going to give us stronger and stronger competition, and we must be prepared to meet it, and meet it not on the basis of their state socialism communistic system, but on the basis of what we consider the true American tradition.

I would like to present to you 1 or 2 recommendations. I understand that almost every witness has presented some, and I would not like to break the record on this matter.

One of the things that I think is very important in education, particularly in education in science, is motivation. In the Soviet Union one aspect of the motivation is the public recognition of a scientist in Soviet society, and his high economic status. In this country it so turns out that the people in the educational institutions who originate the ideas in many of the fields, who are responsible for many of the achievements that have been made, live on the marginal economic basis.

I would like to recommend as an incentive to youth and as a recognition of the importance of these people to our economic life and to our society, that about a hundred Federal professorships be established and given to outstanding people, not only in science, but in other cultural fields, in order to stimulate intellectual leadership in this country.

There have been very many programs to support students—fellowships, teachers, money to educational institutions for research, package reactors, demonstration kits and the like. On the other hand, I think we ought to start looking at building up the intellectual leadership of the country. This would focus the attention of the country on the problem of Soviet challenge. One such focus would be to set up a Federal professor, to hold his position at whatever university he would happen to be in. This would be an equitable way for the Federal Government to support science and leadership in other fields, where it is done on merit alone, and can be done on a very, very high level.

This is the suggestion I would like to present to the subcommittee. Thank you.

Representative PRICE. Thank you very much, Doctor. We certainly appreciate your appearance here, and the fine statement you have made. I think you have given us some valuable information.

Mr. Van Zandt, do you have any questions?

Representative VAN ZANDT. Getting back to Geneva again, Doctor, do you think that the information that we obtained at Geneva as to the ability of their scientific delegation was probably more information than they secured about us?

Dr. TURKEVICH. About us or about things?

Representative VAN ZANDT. Let us say things.

Dr. TURKEVICH. Again I am going to stress this point, Mr. Van Zandt, that leadership is expensive. We found out who our competitors were. We got, I think, a very wholesome respect for their ability. Soviet science has a very characteristic approach, and it is the characteristic Russian mentality. The French have one approach. We have another. We got quite a bit out of their approach, in evaluating and appreciating their ability.

On the other hand, they certainly learned a number of things from us. But they would be, I think, things that they would ultimately learn anyhow. As we are moving into this new age—the nuclear age—with scientific and technological competition getting stronger and stronger, we have to also consider what impressions we are making and what contributions we are making to the life of the neutral countries, and to the life of our allies.

Representative VAN ZANDT. Thank you, Doctor.

Representative PRICE. Thank you very much, Dr. Turkevich. We appreciate your appearance here.

At this point we will insert the report entitled "Problems in Mathematical Education" referred to on page 327.

PROBLEMS IN MATHEMATICAL EDUCATION

By Henry S. Dyer, Robert Kalin, and Frederic M. Lord, Educational Testing Service, Princeton, N. J., 1956

(The publication of this booklet and the study on which it is based have been made possible by a grant from the Carnegie Corporation of New York.)

PREFACE

Late in 1954, the Carnegie Corporation of New York asked Educational Testing Service to describe the kinds of research activities which would lead to better mathematics courses and teaching in the elementary and secondary schools. This booklet attempts to define the problems in terms of what has been written and said on the subject and to locate the areas that need the attention of research.

The evidence and the opinions available to us were, as might be expected, various and often conflicting. There is fairly general agreement that mathematical education is in trouble, but considerable disagreement about what is wrong. We have tried to balance the several points of view against one another and against certain clear facts in order to reach conclusions of our own about the general state of affairs and about what needs to be done. If we appear overcritical, it is probably because we have concentrated on the trouble spots that need attention. We hope not to offend anyone who earnestly supports the cause of better mathematical education, but we shall not be surprised if some of our friends and correspondents disagree with us. In any case, we are deeply grateful to all of them for their cooperation, for without it, this report could not have been written.

The survey was conducted under the direction of a committee made up of Samuel S. Wilks, of Princeton University, and the following staff members of Educational Testing Service: Warren G. Findley, William G. Mollenkopf, and the authors of this booklet. The deliberations of this committee resulted in a multilithed report (205) prepared with the helpful suggestions of Dr. Naomi Stewart. Although based on much of the material in that report, the present booklet does not necessarily reflect the views of the committee as a whole but only of the present authors who assume full responsibility for what has been set forth in the pages that follow. One of the authors, Robert Kalin, a former teacher of secondary school mathematics, carried most of the load of reviewing the literature, consulting the experts, and observing classroom instruction in mathematics.

The limits of the survey may best be understood in terms of a series of numbers. Some 250 books and articles were reviewed. Questionnaires were returned by 14 teachers of college mathematics, 13 educationists, 11 teachers of mathematical education, 7 high school teachers, 8 psychologists, 5 high school administrators, 2 engineers, and 2 social scientists; 9 of these people and 18 others in mathematics or in psychology were consulted by visits, and 6 other specialists by personal letter; 60 classrooms located in 18 schools in 8 school districts in 5 States were observed; 36 of these were at the elementary level, 24 at the secondary level. During these visits teachers and administrators were questioned about the day-to-day problems they were facing in mathematics instruction.

For the reader who may be interested in retracing our steps through the literature a reasonably full bibliography is appended at the end. Not all of the titles are referred to in the text; those that are have been cited by number in the footnotes.

HENRY S. DYER,
ROBERT KALIN.
FREDERIC M. LORD.

In the past few years there have been rumblings of dissatisfaction with the teaching of mathematics. Some hard words have been said on the subject, like these from the New York Times of June 20, 1955:

"At the grassroots of our society, in the schools where our young people are being trained for their responsibilities tomorrow, there are dry rot and decay which threaten not only the bright economic prospects before us but even our ability to remain strong and defend ourselves. We need scientists, mathematicians, and engineers as never before, yet many teen-agers with the ability to assume such roles are simply not being given a chance to get the essential training. The statistics make plain that great mistakes have been made in thousands of communities throughout our land."

This is a serious indictment. It charges that the schools are falling down on an important part of their job, that at the very time we are increasingly dependent on competence in mathematics, many capable youngsters are denied the training they need. Recent studies tend to fortify this conclusion. (20, 22, 23, 111, 248) Complaints from businessmen emphasize that even the most elementary skill, facility in ordinary arithmetic, is in short supply.

Are the schools really falling down on the job? Or is an unusual social and economic situation creating cross-rip currents of supply and demand which make our expectations unreasonable? Is it possible that the limit of what education and training can do has about been reached? If so, where do we go from here?

We have sought to examine these questions with the help of the literature on the subject of mathematical learning and teaching and the opinions of authorities in mathematics, psychology, and education. We tested the accuracy of our impressions gained from these sources by taking a firsthand look at what is actually happening in 36 elementary and 24 high-school classrooms around the country. From what we have read, heard, and seen of mathematical education up through grade 12 there emerges a fairly clear and disturbing picture.

This picture has three main elements—the learner, the teacher, and the mathematics curriculum. Each has its trouble spots; each should be amenable to improvement.

THE LEARNER

The average person does not get very far in mathematics. In elementary school, he goes through the basic operations in arithmetic, but after entering high school, he tapers off fast. According to a recent national survey of high school seniors,[1] 12 percent of them had never taken any algebra or geometry; 26 percent had quit studying mathematics after 1 year, and another 30 percent has dropped the subject by the end of the second year.

This backing away from mathematics can probably be explained in part by lack of mental ability. A great many youngsters, possibly a majority, do not have what it takes to cope with the abstract thinking mathematics demands. But this is only part of the explanation. Many of those who rate well above average in intelligence do not pursue the subject as far as they might. The survey mentioned above shows that 6 percent of the brighter seniors (the top 30 percent on a test of mental ability) do not give either algebra or geometry a try and another 41 percent never get beyond the elementary phases. The reasons such students give for abandoning mathematics are honest, interesting, and sharp enough to be handled with care. They just don't like the stuff; they are afraid of it; they don't see any point to it; they like other subjects more; they are fed up with math teachers (205). Several other studies suggest that mathematics has the dubious honor of being the least popular subject in the curriculum (160, 205).

Part of the difficulty seems to lie in the fact that we are still groping for the psychological principles that govern the learning of mathematics. We know a good deal about the psychology of language. We have come a long way in the psychology of reading. But we have, by contrast, only the rudiments of a psychology of mathematics.

At the risk of oversimplifying a complex of theories one can say that there are two popular schools of thought on the matter—the associationists and the field theorists.

The associationists trace their lineage to E. L. Thorndike, who in the twenties expounded at length about the nature of learning in general and mathematical learning in particular. He wrote three books on the subject (215, 216, 217), which reflected his belief that all learning is a process of establishing a mental

[1] A survey made for the National Science Foundation by Educational Testing Service in 1955. Report in preparation.

connection, or what he called a "bond," between a stimulus and a response. Given the stimulus "3+2," the learning problem is to get it tied tightly and forever to the response, "5." This is done by massive repetition with appropriate rewards when the learner masters or associates the right response to the right stimulus. The learning of mathematics is thus a cumulative process which consists, in Thorndike's words, of "forming and strengthening an immense number of bonds or connections between the sequence of numbers in counting, the items of the addition and multiplication tables, the rules of algebra, the experiences of line and figure, and so forth" (216).

Although this point of view is now generally out of favor with educational psychologists, some experimenters are still working in the associationist tradition. One of them, B. F. Skinner, in a paper appearing in 1954 entitled, "The Science of Learning and the Art of Teaching," (196) has made some rather striking suggestions.

There are two principal ideas in Skinner's theory, immediate "reinforcement" of right responses and careful "programing" of the learning tasks a student is expected to perform. "Reinforcement" comes close to Thorndike's "reward." To say "That's right!" immediately after a pupil has put a "5" after the expression "3+2= " is to reinforce the right response. Skinner emphasizes that reinforcement must be immediate if it is to have any appreciable effect in building the pupil's firm control over mathematical phenomena. He claims furthermore that under usual classroom conditions the "That's right!" is necessarily so long delayed that its effect as a reinforcer is largely lost. Under optimum conditions, every time a pupil makes a right response, whether in a test or a classroom exercise or homework, there must be some way of whispering acknowledgment and approval in his ear within seconds after the response is made.

The principle that learning tasks should be programed is also an important ingredient of Skinner's theory. The trick is to arrange them in such order that when a pupil hits on the right response to one task the chances will be all in favor of his striking the right response to the next. Having worked up by easy stages to the task 3+1=?, for instance, he might next be confronted with 3+?=4. By similar short steps presumably he might one day reach the task

$$\int \frac{d\psi}{5-4\sin\psi}=?$$

in a frame of mind to handle it with ease, relish—and dispatch.

Skinner holds that lack of suitable programing leads in many cases to an excessive number of failures, which in turn produce discouragement, anxiety, and an enduring dislike for mathematics. The working out of sequences which according to this theory would be appropriate for pupils of various ages and degrees of brightness remains to be done. When completed, they should, according to him, provide the means whereby every pupil would not only achieve a solid understanding of mathematical processes but also pleasure in their performance that would last a lifetime.

Skinner has faced the problem of making his ideas practicable by devising a gadget which enables teachers to present each pupil with a set of closely programed tasks and provide him with instantaneous reinforcements. A small box with a window in the top through which a single question or problem printed on paper tape can be seen enables the pupil to select an answer by moving one or more sliders that carry the digits 0 through 9. When the answer has been set, the pupil turns a knob. If the answer is correct, the knob turns freely and a bell rings to inform the pupil he is right. If the answer is wrong, the knob cannot be turned, the bell does not ring, and the pupil must try again. With a device of this kind to help him, according to Skinner, the teacher should be able to arrange matters so that every pupil could work on the tasks best suited to him and could move ahead at a rate most appropriate to his powers.

This approach, however, runs against the current fashion in learning theory as applied to mathematics. At about the same time Thorndike was expounding his views on associationism, a rival school known as Gestalt psychology and founded by Max Wertheimer was advancing the claims of "field theory." Wertheimer later came to this country, experimented with his ideas while teaching, and wrote a provocative little book, (236) demonstrating among other things the use of field theory in geometry. Meantime, T. R. McConnell had summarized the relationship of the theory to the learning of elementary arithmetic. (140)

Field theory claims that learning is not so much a matter of establishing connections between stimuli and responses as it is of finding patterns in the stimuli perceived, that is, seeing some sort of organization and meaning in the

field of experience. Suppose, for instance, that a child is faced with the problem of subtracting 57 from 92. One highly favored line of attack is the decomposition method, which can be taught in different ways. One of them goes like this:

> Since we can't subtract 7 from 2, we borrow 1 from the 9 and put it in front of the 2. This turns the 2 into 12 and the 9 into 8. We can now go ahead and subtract 7 from 12 and 5 from 8, thus:

$$\begin{array}{r} {}^{8}\not{9}\,{}^{1}\not{2} \\ 57 \\ \hline 35 \end{array}$$

The field theorists do not like this approach because it is arbitrary and mechanical. The child performs the operations without getting any real understanding of why he does what he does. They would therefore present the problem somewhat like this:

> Since the 7 is larger than the 2, we can't just go ahead and subtract in the usual way. Let's look the situation over and see what we have. 92 is really 9 tens and 2 ones. Also, 57 is really 5 tens and 7 ones. So the problem is actually this:
>
> 9 tens and 2 ones
> take away 5 tens and 7 ones.
>
> The trouble is that we can't take away 7 ones from 2 ones. What can we do? Well, we know that 9 tens and 2 ones is the same thing as 8 tens and 12 ones. Hence, we can write the problem like this:
>
> 8 tens and 12 ones
> take away 5 tens and 7 ones.
>
> Now we can go ahead and subtract: 7 ones from 12 ones leaves 5 ones; 5 tens from 8 tens leaves 3 tens. So the answer is 3 tens and 5 ones, or 35.

The second way of approaching the problem takes a little longer, but the field theorists argue that the extra time is well spent, since the pupil is more likely to get a firm grasp of what is going on and will therefore be better able to deal with similar problems in the future. He will begin to get the idea that mathematics is more a matter of reasoning than of memorizing arbitary rules of thumb. And once he accepts and exercises this idea he will be able to move ahead farther and faster and with increased feelings of satisfaction in what he is doing. He will see that mathematics makes sense.

A considerable amount of experimentation, notably by W. A. Brownell, has been done to test the field theory approach to some aspects of mathematics in the elementary grades, and there is strong evidence that under certain conditions it is more effective than straight drill (2, 24–38, 44, 203–207, 213, 214, 237–239). One significant attempt to apply field theory to arithmetic on a broad scale is proceeding under the direction of Laura K. Eads in the New York City schools, but although there is much enthusiasm for the theory, little has been done with it beyond the early stages of the elementary school. One of the big questions still to be settled is how it is possible to tell when the elements of a mathematical problem look really meaningful to the learner rather than just to the teacher (48, 203, 236).

Much more and closer observation of the ways individual children develop their ideas of number and of logical relationships as they grow up is needed to clarify the psychological processes involved in learning mathematics. The work of the French psychologist Jean Piaget (168–170) is indicative of the direction that this kind of research might take, but a good deal more along the same line remains to be done. Both the associationists and the field theorists face the problem of moving above and beyond the plane of theory in order to describe in highly concrete and specific terms the whole series of mathematical tasks that will breed at every step in each school grade a maximum of new insights and understanding and a minimum of confusion.

The chances are that the associationists and field theorists are not so far apart as their controversies make them appear. It is conceivable that in the strengthening of all the various kinds of learning connected with mathematics both theories have important roles to play. The definition of their roles, however, should emerge not only from theorizing but from a long series of closely con-

trolled, well-coordinated experiments with children as they progress from year to year. Until these experiments have been performed, the question of how youngsters may best learn mathematics will remain up in the air.

One writer after reviewing the research on mathematics instruction to 1953 is forced to the conclusion that "no decisive proof that any particular method of teaching (inductive, deductive, individual, group) or any particular philosophy of teaching will guarantee better results than any other method or philosophy, so far as achievement is concerned" (71). The reason for the lack of conclusive results, as he sees it, is to be found in the inadequacy of the piecemeal research that has been done to date.

Some people have suggested that youngsters who have trouble with mathematics and abandon it as soon as possible may be bothered by emotional problems and personality quirks. Although the evidence on this point is skimpy, there is enough to make one wonder. One remedial clinic studied 22 children who were behind in arithmetic and decided that for perhaps 15 of them the basic difficulty was emotional. (110) Nagging parents, or the snowballing discouragement that comes of always getting wrong answers, had generated so much anxiety in the youngsters that they were afraid to try. Another investigator observed 13 children retarded in arithmetic and came to the conclusion that bad personal adjustment rather than low intelligence or poor teaching was the principal cause. (171) Two other studies, however, seem to support a somewhat different notion, namely, that mathematics is a refuge for introverts and those who have trouble getting along with others. (161, 185)

These notions are straws in the wind. They point to the fact that failure in mathematics, like any sort of failure, is apt to have emotional overtones. But many questions remain. Three big ones are those: (1) What kinds of emotional disturbance, if any, are specific to mathematics? (2) What is their incidence in the school population? (3) How may cause and effect in the situation be disentangled? We could also profit from more knowledge than we now have about the relation to mathematical learning of such factors as home background, parental attitudes, and biological inheritance. More definite knowledge of all these matters, as well as of the learning process itself, is needed if we are to get a reasonably full understanding of what it takes to develop competence in mathematics.

THE TEACHER

During the early stages of the survey on which this report is based, articles in the newspapers described its purpose. One elementary-school teacher, reading about it, wrote in to wish us luck. She said she had always dreaded mathematics and had to be constantly on guard to keep from inducing the same fear of the subject in her pupils.

At least one study (77) supports the presumption that this teacher is not alone in her predicament. It showed that of 211 prospective elementary-school teachers, nearly 150 had a long standing hatred of arithmetic.

This state of affairs may not be unrelated to a lack of ordinary competence with numbers. A random sample of 370 candidates for elementary school positions faced this question on an examination:

> The height of a letter in a certain size of print is ¼ inch. If the following are the heights (in inches) of this letter in other sizes of print, which one is the next larger size? (a) 5/16 (b) ½ (c) 3/76 (d) ⅜ (e) 7/16

Half of the 370 candidates picked a wrong answer. (205)

There have been numerous studies of teacher competence in arithmetic. If they can be believed, it seems pretty clear that many elementary schoolteachers have a hard time keeping even half a jump ahead of their pupils. Their salvation lies in memorized answers, rather than in any genuine understanding of arithmetic concepts. "Elementary teachers, for the most part," according to one observer who has taught them, "are ignorant of the mathematical basis of arithmetic; high-school teachers assigned to teach matematics fall in this category also." (205)

This ignorance is scarcely surprising, for little knowledge of mathematics is expected, even officially, of prospective school teachers. In the majority of cases an individual with ambition to teach in an elementary school can matriculate at a teachers college without showing any high school mathematics on his record. He can graduate without studying any college mathematics. And in this condition, he can meet the requirements of most States for a certificate to teach

arithmetic. (93, 131, 183) The certification requirements for high school math teachers are only a little stiffer: (131, 245) nearly one-third of the States will license them even though they have had no college mathematics at all, and the average requirement for all States is only 10 semester hours.

No doubt many teachers go beyond the certification requirements in preparing for their job. One can suppose, however, that there are plenty of others who yield to human nature and stop at the minimum. In addition to these there is an unknown number on so-called emergency certificates who have not yet attained the minimum. (64)

There is one point of view which insists that courses in how to teach, as opposed to courses in straight subject matter, are generally a waste of time, if not worse. Not many candidates for elementary school positions, however, have to "waste" much time taking courses in how to teach arithmetic. Four-fifths of the liberal arts colleges which have departments of education, one-half of the colleges of education, and one-third of the State teachers colleges do not require such a course. (93) Many of these places do require their students to take courses in general teaching methods, but this is a far cry from courses aimed specifically at the strategy and tactics of teaching arithmetic. On the other hand, practically all trainees for high school mathematics teaching get some sort of course on how to present the material, although there is little agreement among the States about the method of presentation. (131)

One writer after looking over the situation says, "Some of the most popular instructional practices (in arithmetic), to say nothing of the inferior ones, are not in quality the equal of methods in other fields in the elementary school, and some lag far behind learning theory." (201) In view of the status of mathematical learning theory, as it has been sketched above, one wonders how the situation could be much different. It is hard to see how sound rules of practice can even be formulated until something more substantial than controversy attends the description of how children are most likely to learn mathematics.

Some people have an affection for the popular cliché that "a good teacher is born, not made." This does not mean that a good mathematics teacher can be devoid of subject-matter knowledge or uninitiated in the techniques of imparting it. But it does imply that something more is required for effective teaching, namely, enthusiasm for the job and a sound personality. This seems like good common sense, but what does it involve? What do we really know about the role of personality factors in teaching? Not much. One reason for this is that we have yet to discover sufficiently dependable methods for assessing personality. Another is that the criteria of effective teaching are hard to pin down. If a teacher's personal makeup cannot be defined, and if it is impossible to tell with certainty what effect he has on pupils, the task of tracing connections that may exist between what the teacher is and how much the pupils learn is not very easy. A few investigators have tried, but their findings are not very helpful. (190)

With respect to the pupil's actual progress in mathematics, very little indeed is known about the relative effects of the teachers' background in subject matter, his training in instructional methods, his personal qualities, or his attitude toward the job. It is even conceivable, in the absence of concrete evidence one way or the other, that the whole difference between successful and unsuccessful mathematics students has nothing to do with the teacher at all, but can be accounted for solely by the pupil's potentiality for intellectual growth and the influences that play upon him outside the school walls.

This is conceivable but not likely. Measured in time alone, the teacher's place in the intellectual environment of his pupils is singularly important. What he knows or does not know, what he does or does not say and do in the classroom can hardly fail to have a considerable influence on what happens in the minds of the pupils. Despite the thinking and research that have been going on for a good many years, however, we still have an imperfect understanding of what a teacher ought to know, what he ought to say and do if his pupils are to achieve up to their limit in mathematics. This understanding is less likely to come from speculation and argument than it is from some comprehensive and well-controlled research.

In the absence of data, let us accept the assumption that a teacher who has a solid understanding of mathematics himself is more likely than not to develop a similar understanding in his pupils. Where does such an assumption take us? In a vicious circle, apparently, and in reverse, for it has been shown that this solid understanding is frequently absent in teachers. Future teachers pass through the elementary schools learning to detest mathematics. They drop it in high school as early as possible. They avoid it in teachers' colleges, because it

is not required. They return to the elementary school to teach a new generation to detest it.

How can the circle be broken? Toughening up requirements for professional certification might help, but it would be at best only half the solution. Stiffer requirements would exclude a lot of people deficient in mathematical background, but they would not produce the numbers so desperately needed to man the rapidly multiplying classrooms of the Nation. A much more direct attack on the problem is needed, a kind of remedial mathematics for teachers of mathematics designed to unravel the teacher's numerical neuroses, to nourish him on the whys and hows of mathematical phenomena, and to liberate him from the confinements of the textbook so that he may enjoy a lively appreciation of the thousands of important uses that mathematics has in the modern world. With that quality and freshness of understanding, he could go back to the classroom and start the circle turning in the right direction toward a new generation sure-footed in number and delighting in mathematical concepts and the power of abstract reasoning.

This is a pretty picture but far from realistic. Not all the trouble in mathematics can be eliminated by retraining teachers, even if a good retreading process were known. When our observer visited 60 classrooms to verify at first hand what the books and the experts were saying about the deplorable state of mathematics teaching, he found 10 in which the teaching was reasonably effective; in the other 50 the instruction was so confused that learning of any kind seemed to be largely accidental and unillumined by any learning theory whatever. Perhaps our man happened to hit a peculiarly unattractive sample of schools. Maybe he expected too much, or saw too little. Admittedly, this brief glimpse at a few pieces of a very complex jigsaw puzzle cannot be relief upon as a fair representation of the whole picture.

In any case, the teachers themselves could not be censured for the conditions under which they work. Most of them were struggling with classes of 35 to 40 pupils who sometimes spread over 2 different grade levels and almost always ranged widely from the bright but bored to the dull and bewildered. It takes more than brains, good will, and a sparkling personality to conquer this kind of situation. It takes a fundamental change in the conditions of teaching—a change that only the public, acting through its representatives on school boards, can bring about.

THE CURRICULUM

Between the pupil and the teacher is the mathematics curriculum, the prescription of what pupils should learn and teachers should teach. To be a useful prescription, the curriculum needs to be in vital contact with at least three areas of reality: the growing body of knowledge in the field itself, the specific mathematical needs of the sciences and professions, and the minimal understanding of mathematics an ordinary person must develop if he is to live comfortably in a technical culture. At the same time, the curriculum must take account of the ways pupils learn. That is, subject matter, from bottom to top, must be arranged so that the steps leading for simpler to more advanced concepts will seem reasonable and natural to the learner.

All this suggests that the mathematics curriculum must grow with the times. The fact is that it has changed very little during the past century. The elementary school has offered arithmetic and some intuitive geometry; the college preparatory curriculum in high school has generally consisted of algebra in grade 9, demonstrative geometry in grade 10, more algebra in grade 11, and trigonometry, solid geometry, and occasionally advanced algebra in grade 12. (20) There have of course been some variations on this pattern and changes of emphasis in some schools from time to time, but by and large the mathematics curriculum in general use today looks remarkably like the 1890 model.

Practically everybody who has given thought to the matter seems to agree that the mathematical topics in the elementary school—ancient though they are—are still appropriate for the younger children. But most of the same people also agree that the manner in which this content is organized leaves much to be desired. There is a good deal of suspicion and some evidence that the usual sequence in arithmetic may not be in line with the natural development of the pupils. (40, 128, 151, 206, 228) Too often they are either expected to wrestle with mathematical ideas before they have grown enough to handle them successfully, or they are forced into work that is intended to keep them busy but is so easy it lacks any real challenge or satisfaction. A considerable amount of attention has been given to this problem, but the investigators most deeply involved are the first to admit that its solution will require much study and experimentation. (213)

A closely related problem is that of getting enough flexibility into the arithmetic curriculum to serve the bright, the not-so-bright, and the dull equally well. Most school authorities probably recognize that some pupils can learn arithmetic much faster than others, but recognition of the phenomenon is a long way from knowing how to cope with it in actual classroom practice. Some schools have tried grouping students according to ability in one way or another, but for various reasons have found it expedient to abandon this device. Opinion now favors "enrichment" for the abled pupils—giving them something interesting to do while the slower students are being brought up to par in the regular subject matter.

The idea of enrichment is attractive, but in mathematics it has not worked out very well, or at least the ways to make it work seem to have eluded most teachers. Suitable materials are scarce, and the few that do exist have not meshed smoothly with the rest of the curriculum. The child who whips through the day's assignment and looks around for new worlds to conquer too often is told to spend time retracing his steps with similar tasks. He is not allowed, much less encouraged, to explore territory which will keep his mind fully active (176). Part of the reason for this may be the teacher's fear of getting into an unmanageable situation. If the bright youngster is given his head, the chances are that he will move forward so far and so fast that the gap between him and his classmates will become more embarrassingly wide than it already is. Nobody seems to have come up with a solution to this problem which the ordinary teacher, confronted daily with the wriggling realities of the classroom, is wholly ready to understand and to accept.

In recent years, one attempt to handle the elementary mathematics curriculum differently has been to abolish it altogether as a separate entity by teaching arithmetical concepts wholly in the context of activity programs and experience units. In this scheme arithmetic is integrated with such subjects as social studies and science, and taught as their need for it arises. Supposedly, this helps the pupil to see mathematics as a useful tool, instead of as a set of arbitrary operations isolated from the real problems of life. But several studies of this approach suggest that incidental learning of arithmetic is not enough learning. Ernest Horn, writing for the committee on the teaching of arithmetic of the National Society for the Study of Education, summarizes the studies thus: "After careful appraisal of such evidence as does exist, and after giving full credit to what has been done or is likely to be accomplished under integrated plans, such plans by themselves cannot be depended upon to develop arithmetical concepts and abilities to the level and scope required in life" (112).

Although much is yet to be learned about how the elementary school curriculum in mathematics can best be organized, some encouragement stems from the fact that a good many people have been worrying about the situation and trying to do something about it. Unfortunately, this has not been true of high school mathematics until very recently. Over the years there have been repeated recommendations for change, but by and large the offerings at the secondary level have remained static. Among the recommendations were those of the so-called Committee of Ten in 1894 (180), the president of the American Mathematical Society in 1902 (193), a national committee on mathematical requirements, under auspices of the Mathematical Association of America, in 1923 (153), a joint commission of the Mathematical Association of America and the National Council of Teachers of Mathematics in 1940 (117), the commission on secondary school curriculum of the Progressive Education Association of America, also in 1940 (62), and the commission on postwar plans of the National Council of Teachers of Mathematics in 1945 (61). There may have been others as well.

The substance of these recommendations has varied in detail, but there have been three persistent themes: first, take the traditional subjects of algebra, geometry, and trigonometry out of their watertight compartments and unify the mathematically important topics into one naturally related development; second, bring such subjects as analytic geometery, statistics, and the calculus into the secondary school curriculum; and third, set up a double-track program—applied mathematics for the student not headed for college, and a 2- to 4-year integrated sequence for the college-bound student.

The continuous pressure to reform the secondary school curriculum in mathematics has had only one noticeable effect: the growth of a ninth grade course for slow learners called "general mathematics." This course has been conceived in different ways. Some people have thought it should develop an elementary understanding of algebra and geometry; others have thought it should deal

with those topics the ordinary person needs to know in order to conduct his daily affairs. In practice it has usually become a final attempt to pound home the basic operations of arithmetic,(54, 116, 135) an experience which teachers have not found exciting. Students, too, look down their noses at general mathematics, but take it to avoid algebra. It is a development that may have met the needs of less able students, though at least one study suggests that even this is doubtful.(12)

Until very recently, no similar effort has been made to raise the abler high-school students to the point of mathematical literacy that should be expected of them. It is true there have been isolated instances where they have been introduced to statistics, analytic geometry, and the calculus.(1) And a few brave attempts have been made to break down the walls between algebra, demonstrative geometry, and trigonometry by reorganizing the same subject matter around a set of primary mathematical concepts. But by and large, most students who stick with mathematics throughout the 4 years of high school follow the same ruts their grandfathers followed before them. The high-school curriculum today shows few, if any, signs of the important developments that have taken place in mathematical science since the 17th century.

Repeated urgings to move first year college mathematics down to the high school have had little effect. Instead, the trend, if one can call it such, has been in the opposite direction: colleges protest that they are often forced to teach high-school algebra to their freshmen. One study shows that 62 percent of the colleges are in this position.(243) An engineering school reports that 72 percent of its students entering in September 1955 were found so mathematically inadequate that they had to take a review of high school mathematics before they could qualify for the regular freshman course.(78)

Currently there are several major efforts to change and improve secondary school mathematics. One which is under the auspices of the University of Illinois Committee on Secondary School Mathematics has assembled a working staff and consultants consisting of research mathematicians, mathematics educationists, engineers, and high-school teachers of mathematics who are trying to develop a feasible 4-year course that reflects modern developments in mathematical theory and applications. They are putting together an integrated course of study and trying it out in classrooms, revising the plan as they go along. Textual materials and teachers' manuals for the 9th and 10th grades have been completed and are in use in several public schools. The committee claims that the course is psychologically sound, suited to capable high school youngsters, in spite of including some advanced concepts, and stimulating to those who have previously shown a distaste for mathematics. Full substantiation of the committee's claims, however, cannot be made until the 11th and 12th grade sections of the course have been produced and a thoroughgoing evaluation of the program has been carried out.

A second attempt to lift the level of the high-school mathematics curriculum was undertaken by the School and College Study of Admission with Advanced Standing, organized in 1952. (227) It sought, among other things, to develop a secondary school mathematics course for gifted students which would enable them to undertake sophomore work upon entering college. A number of schools are participating in this experiment, reworking their mathematics offerings in grades 10 through 12 to carry the student well into the calculus by the time he graduates. A considerable proportion of the students who passed through the first year of the program were granted placement in college sophomore courses, and the record indicates that none of them encountered serious difficulty. (80) This program is continuing as the advanced placement program under the auspices of the College Entrance Examination Board.

A third approach has been the establishment by the College Entrance Examination Board of a commission on mathematics, a group of acknowledged authorities in college and high school mathematics. Their charge is to survey the present state of the high school curriculum in detail, to work out desirable changes for it, and to develop plans for retraining teachers to undertake the revised program with their classes. This long-range project is just getting underway.

Two other activities, the science teaching improvement program of the American Association for the Advancement of Science and work of the curriculum committee of the National Council of Teachers of Mathematics are also aimed at vitalizing the mathematical offerings of the secondary schools. Reform is in the air. There seems to be a good chance that the high-school curriculum in mathematics will in the next few years undergo some improvements.

THE BIG NEED

Efforts to remake the curriculum are all to the good, but curriculum revision strikes at only one side of the trouble in mathematical education. Much more needs to be known about the mental functioning of children who are expected to pass through the curriculum and about the teachers who are expected to operate it.

Many things will have to be done and discovered before the general population can achieve literacy in mathematics comparable to its literacy in the mother tongue. Not the least of these should be a campaign to correct popular attitudes toward the subject. People must be brought to realize that in these times a command of numbers can be just as important as a command of words. More first-rate mathematicians should be speaking directly to the public in terms that can be understood. Most people have no conception of the nature and scope of mathematical science, of the power it wields in coming to grips with the complexities in the world around us, or of its potentialities for bringing straight thinking into problems of human concern. If only a fraction of the money and skilled effort spent in advertising other things were devoted to acquainting the public with the true importance of mathematics, there would be less difficulty getting support for school budgets adequate for improved instruction.

Improved instruction, however, will depend in the long run on achieving a better understanding of the facts of the situation than we now have. Too little is known about how the minds of children can be brought to cope with mathematical concepts. Too little is known about what it takes to make them want to use mathematics. Too little is known about whatever it is that differentiates an effective teacher from one who is less effective. Too little is known about manageable ways of organizing the subject matter of mathematics so that the able will be challenged and the less able will not be discouraged.

Some hunches about these questions are on tap, but most of them are unconfirmed. To test the hunches and uncover the important variables in mathematical learning and teaching some comprehensive long-range research is needed. Until now practically all such research has been so piecemeal and scattered that it has not added up to much that is practically helpful. It is not possible to get very useful answers by looking at only one aspect of the problem at a time. Account must be taken of the complex interplay of a whole host of variables: the pupil—his background, attitudes, habits of thought, developing characteristics; the teacher—his training, interests, behavior in the classroom; the curriculum—its content, organization, goals, adaptability to the actual learning-teaching situation. And the research must include the crucial dimension of time. It must conceive of mathematical learning as a developmental process that goes on all the while an individual goes to school, and before and after his schooldays.

This calls for a coordinated research effort which is feasible if those now expert in the several pieces of the problem can become intelligible to one another and join forces long enough to map out and execute the interrelated lines of investigation. Mathematicians, psychologists, educationists, classroom teachers, and such consumers of mathematics as physicists, engineers, and economists must put their heads together, not for a day or a week, but for as long as is necessary to get experimental studies going and keep them going until hunches can be converted into verifiable conclusions based on actual data from classrooms and training centers.

Such a cooperative undertaking is possible. The work of the Illinois committee mentioned above shows what can be done. So does the work of another group at the University of Chicago (205) where college mathematics teachers, educators, and psychologists met together regularly over a 2-year period to study the psychological problems of teaching and learning mathematics. This particular project has special relevance, not only because of the types of problems it uncovered but because it formulated these problems in the context of an on-going program of study which attempts to make modern mathematical logic an integral part of the general student's regular thinking.

The suggestion that the way out of the mathematical mess is through educational research is likely to try the patience of those who want immediate action. In the present instance, fortunately, much of the research that makes sense implies immediate action. It involves stimulating and training teachers to try out new ideas in the classroom, studying the responses of students to see how the new ideas are taking hold, and measuring each step to see if the differences produced are worthwhile and permanent. This is the sort of experi-

ment in which the guinea pigs (the pupils and the teachers) derive fairly immediate benefits when and if there are any benefits to be derived. The main difference between research and reform, in this case, is that the research insists on organizing the reform in such fashion that it can be determined whether the changes are really changes for the better.

There is, however, another kind of educational research that also makes sense—the kind that seeks a clear description and a fundamental understanding of the controlling factors in learning and teaching. It expects no immediate payoff in the form of an action program; it seeks only to clarify the complex relations that exist among the learner, the teacher, the curriculum, and the social milieu in which mathematical education is expected to take place. It takes nothing for granted but by patient exploration endeavors to expose the blind alleys as well as the highways by separating truth from mythology in educational thinking. It requires the collection and analysis of mountains of data on every conceivable aspect of the educational process. The findings accumulate slowly and are unlikely to appear sensational as they occur, but they are indispensable if ever there is to be a dependable body of verified knowledge for the guidance of policy and practice.

Research of this kind is often called "basic" inasmuch as it tries to arrive at underlying laws and principles. Education in general has known little of this type of research, and mathematical education in particular has known even less. It gets lipservice, but not much sustained attention or support. The trouble is partly lack of funds, partly a failure by the public really to appreciate its fundamental importance, partly the pressure of day-to-day routine on the schools and on the researchers.

Thus, the big need is for comprehensive research—research in the process of learning mathematics and in all the factors that affect it one way or another.

Even so, the whole remedy will not be found only in more research. Well-trained mathematics teachers are in short supply—partly for reasons that have been suggested above and partly because the thin stream of students who develop genuine talent in mathematics is almost completely absorbed each year by industry and the technical professions. Not only must the stream be deepened and widened, but more of it must be diverted into classroom teaching, or at least into teaching classroom teachers, present and prospective. Somehow ways will have to be found for making the teaching of mathematics competitive with the other types of employment a mathematician can enter. This means that the rewards for teaching in money and prestige and job satisfaction will have to be greater than they are now. It also means that the mathematics teacher in the classroom will have to be protected from the thousand and one miscellaneous school activities that have nothing to do with his main job.

It will take a generation, perhaps two, to make a sizable dent in the problems of mathematical education. But little will be accomplished even in that time unless those competent to deal with the problems—the mathematicians, the psychologists, the educators—can develop a sufficient cooperative concern to take time off from their ordinary preoccupations and are given the means to come to grips with the situation now.

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Representative PRICE. The committee will be in recess until tomorrow morning at 10 a. m., when we will meet in the same room.

(Thereupon at 4 p. m., Wednesday, April 25, 1956, a recess was taken until Thursday, April 26, 1956, at 10 a. m.)

SHORTAGE OF SCIENTIFIC AND ENGINEERING MANPOWER

THURSDAY, APRIL 26, 1956

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
SUBCOMMITTEE ON RESEARCH AND DEVELOPMENT,
Washington, D. C.

The subcommittee met, pursuant to recess, at 10 a. m., in room 1334, New House Office Building, Hon. Melvin Price (chairman of the subcommittee) presiding.

Present: Representative Price.

Present also: George E. Brown, Jr., of the committee staff.

Representative PRICE. The committee will be in order.

This is a continuation of the hearings of the Subcommittee on Research and Development of the Joint Committee on Atomic Energy on the problem of the shortage of scientific and engineering manpower, particularly as it affects the atomic energy program.

Due to other committee meetings, both of the Atomic Energy Committee and the various other committees on which the members serve, several of them may be late in arriving this morning, but I thought that we would get under way with our first witness, Mr. Philip Coombs, representing the Fund for the Advancement of Education.

Mr. Coombs, would you proceed with your statement? I understand you have a prepared statement.

Mr. COOMBS. That is correct, sir.

Representative PRICE. The committee would like very much to have you present it now.

STATEMENT OF PHILIP H. COOMBS, SECRETARY AND DIRECTOR OF RESEARCH, THE FUND FOR THE ADVANCEMENT OF EDUCATION

Mr. COOMBS. My name is Philip H. Coombs. My statement today at the invitation of the subcommittee is entirely an expression of personal views. It is made, however, against the background of more than 3 years with the Fund for the Advancement of Education——

Representative PRICE. May I ask if in your statement you describe the nature of your organization?

Mr. COOMBS. No, sir.

Representative PRICE. Would you mind doing that for the record?

Mr. COOMBS. Yes, sir. The Fund for the Advancement of Education was established as a philanthropic organization by the Ford

Foundation in April 1951 as a separate corporate entity, with its own board of trustees and officers. The chairman of the board at the present time is Mr. Roy Larson, the president is Mr. Clarence Faust.

The mission of the Fund for the Advancement of Education is to encourage promising new developments and experiments in the field of formal education in a general effort to improve the quality and functioning of our educational system and to expand educational opportunities on an equal basis to all young people. We have been, in the last few years, concentrating particularly upon the problem of improving teaching at all levels.

Representative PRICE. Does your organization provide any scholarships or fellowships?

Mr. COOMBS. Our organization has in the past conducted two fairly large scale fellowship programs. One is for outstanding college teachers already on the job, in order to give them a year off at full pay to pursue a self-designed program of further personal growth. There is a similar program for high school teachers who are selected as being outstanding and promising by their own communities. There have been a few hundred of these fellowships given each year for the last 4 years.

Representative PRICE. About how many would you say are given each year on an average?

Mr. COOMBS. On the order of 500.

Representative PRICE. On the order of 500?

Mr. COOMBS. For the two programs combined. However, those two programs are terminating with the present academic year due to the fact that we have a limitation on our resources, and we felt that we could not maintain these programs and at the same time support experimental efforts in the schools and colleges to help solve some of the very problems your subcommittee is considering.

Representative PRICE. How long has the program been in effect?

Mr. COOMBS. Four years in the case of the college fellowships and 3 years in the case of the high school fellowships.

Representative PRICE. Did you consider them successful and of great value in the type of promotional work you were doing in the field of education?

Mr. COOMBS. We conducted a careful evaluation last spring on both of those programs to check up on just what these teachers did after they got back to their job, and also what they had done during their year off. We came to the clear conclusion that these programs had, in the large majority of instances, improved the individuals concerned as teachers. It was not only refreshing to them to get out of the harness for a year, but it enabled them to grow intellectually and socially, and it sent them back to their schools and colleges with new ideas and new energy. In many instances, these people became the leaders in their own schools and colleges for innovations in the direction of improvement of education. So we felt thoroughly satisfied with the investment that had been made, and did we have the funds available, we would surely feel warranted in continuing these programs.

Representative PRICE. Were they selected from all fields?

Mr. COOMBS. All subject matter fields. There was no weighting given to any particular subject field. The candidates were selected on two principal grounds. One was their own personal qualifications: their quality, past performance, and promise; the second was the

quality and imaginativeness of the particular program they proposed to pursue. It was entirely up to them what they would do for the year.

Representative PRICE. Thank you very much, Mr. Coombs. Will you proceed now with your formal statement?

Mr. COOMBS. This statement is made against the background of more than 3 years with the Fund for the Advancement of Education, at home and abroad, and a longer period of interest as an economist in the problems of manpower. Just prior to joining the fund, I served as Executive Director of the Paley Commission—the President's Materials Policy Commission—which encountered some of the same manpower shortage problems with which your subcommittee is concerned. On the basis of these and other relevant experiences, I wish to suggest the following propositions:

1. The current shortage of nuclear scientists and engineers in the United States is part of a much broader shortage of specialized talent which plagues a variety of fields. Shortages of talent in these other fields, though less dramatic and less highly publicized, may nevertheless be an equally serious impediment to long-run national security and welfare.

2. In the short run, talent shortages in particular fields, including atomic energy, must obviously be met primarily by (*a*) attracting existing specialized talent from other fields, with conversion training where necessary, and (*b*) by increasing the efficiency with which such personnel is presently utilized, particularly by relieving them of functions which do not require their high level of skill and which could as readily be performed by persons of less training or competence.

3. Such reshuffling of specialized talent is a normal and healthy feature of a dynamic and growing economy. But pressed too far it can impose lasting injury upon important fields that are robbed of talent. This is precisely what is happening to our schools and colleges today, to the long-run detriment of all other fields that rely upon our educational institutions to produce an ever-expanding supply of specialized talent of all sorts.

4. Policies that may be justified in the short run, when we are forced to make the best of a short supply of specialized talent, will not produce satisfactory results in the long run. They will tend to perpetuate the shortage, which in turn will dampen the rate of progress on all fronts.

5. The only satisfactory long-run policy is one which aims not at rationing a short supply but at expanding the total supply of specialized talent so that no important field must suffer in order for some particular field to gain.

6. The potentialities of such a long-run manpower policy—aimed both at expanding the total supply and at achieving more efficient utilization of specialized talent—depends upon the extent to which we are now failing to develop our potential human talent and to make the best use of developed talent. By this measure, there seems to be abundant room for improvement.

Our schools and colleges are, on the whole, turning out more and better developed talent than ever before, partly because they are processing more students. But our national need for specialized

talent has grown even faster. The most important point, however, is that the potential talents of a great many other young people—in science, engineering, music, art, literature, economics, politics, and a host of other fields of human endeavor—are not being fully developed today and are therefore being wasted, both for the individuals concerned and for our whole society.

7. The causes of this vast waste of potential human talent are many; hence the necessary measures for reducing the waste are numerous and complex. They do not lie within the province or the sphere of any single congressional committee, or any one level of government, or any one set of educational institutions, or any one type of civic or professional organization. The solution is everybody's business and hence is in jeopardy of being nobody's business. It would help greatly if the Federal Government would exercise leadership by enunciating a clear-cut, long-range policy regarding the development of specialized talent which would help guide all parties, public and private, who share responsibility in this vital matter.

8. Probably no one has the wisdom right now to lay out a detailed and comprehensive program for carrying out such a national policy, though a number of useful first steps are obvious. It is also obvious that we must experiment boldly in the search for solutions, that we must be prepared to substitute many new practices for some comfortable but outmoded old ones—which is always painful—and that, even more painful, we must be prepared to pay the costs in money. But the likely rewards for all this pain and effort are enormous, if we succeed in reducing the present waste of potential ability.

9. There should be no illusions that we can remedy our national shortage of specialized talent quickly. The production cycle for the kind of highly educated, well-trained manpower we are discussing is long at best, and the factors which are preventing the fuller development of our potential human talent are deeply rooted. This fact may encourage postponement of action by those who thrive only on crash programs which promise quick results; but there could be no more serious mistake than to delay an early and vigorous attack on all fronts of this problem. The reason for haste is evident to anyone who has taken even a casual look at what lies immediately ahead for American schools and colleges, and hence for all consumers of specialized talent.

10. What lies ahead—in fact, what already exists—is a combination of forces which threatens to force a deterioration in the quality of American education from kindergarten through graduate schools over the next 10 to 20 years. One of these forces is the rapid rise in school and college enrollments, brought on by the sharp increase in births since the war and by the continued trend toward more years of education for the average young American. Taken by itself, this is a cause for rejoicing, for it means that we are much richer in human resources and are continuing our giant strides toward the democratic goal of universal education. It is essentially the second force in combination with the first that presents the difficulty—namely, the mounting shortage of good teachers, a shortage which promises to get progressively worse each year. This brings us right back to the overall shortage of specialized talent—for it is this caliber of manpower that our schools and colleges need in ample supply if they are to raise the quality of education for all young people and if they are to help develop more fully the potential talents of the ablest.

At this point, Mr. Chairman, I would like to invite your attention to a study recently published by the Fund for the Advancement of Education, entitled "Teachers for Tomorrow." In this study an effort was made to bring together all of the best available data applying to the next 10 or 20 years. It sought to answer five questions.

The first question was:

How many young people will we have to educate in the years ahead at different levels of school and college?
How many teachers will it take to educate this many youngsters?
What are the chances of getting enough good teachers?
What will be the consequences if we fail to get enough?
What can be done toward solving this problem?

Without going into any of the details——

Representative PRICE. Mr. Coombs, as you ask those questions, the subtitles to your sections in your very fine publication, give the figure of what you estimate to be the number of people who will be attending school and college, the number of teachers that will be needed, just as a matter of record here.

Mr. COOMBS. Perhaps, in terms of enrollment it will be most illuminating if we indicate how much of an increase over the present or recent past levels can be anticipated.

Representative PRICE. I think it is important that we have your estimate on this, because this is a field in which your organization is specializing. Is that not true?

Mr. COOMBS. That is true. But I would like to emphasize, in preparing this study we have drawn very heavily upon estimates prepared by the Office of Education, by the National Educational Association, and any other reputable agency or organization that could provide us good figures. The analysis and conclusions are our own.

Representative PRICE. While it may be entirely possible we do have somewhere else in the record such figures, I still think it would be valuable if we have them at this point also.

Mr. COOMBS. Elementary school enrollments rose from 21,130,000 in 1940 to 26,265,000 in the school year ending 1954, an increase of 5,135,000. On the basis of children already born, elementary enrollments will grow by an even larger amount by 1960 to an estimated total of 33,650,000, an increase of 28 percent over 1954. In short, the sharp upswing since the war has not ended.

At the secondary school level, the increase thus far has been milder, from 7,072,000 in 1940 to 7,203,000 in 1954. But the bumper crop of children born late in World War II and thereafter will soon begin to crowd our secondary schools. Enrollments at this level will rise steadily from here on, reaching an estimated total of 12,351,000 by 1968–69, or an increase of more than 70 percent over 1954.

You will find these figures charted on pages 12 and 13 and shown in detail in the back of Teachers for Tomorrow.

College enrollments cannot be predicted with the same degree of accuracy since there is a steady increase in the proportion of college-age young people who are choosing to go to college in this country, but no one knows how that proportion will behave in the future.

Total college and university enrollments rose from 1,494,000 in 1940 to 2,478,000 in 1954. Over that period there was an average increase each year of 1 percent in the proportion of college age young people

actually going to college. If the latter trend continues, then college enrollments will reach double the 1954 level by 1966. Even if the proportion of young people going to college rises very little from here on, which seems unlikely, total enrollments will reach twice the 1954 number by 1971.

In short, then, these enrollment projections indicate that American schools and colleges must be prepared to handle a far larger clientele in the years ahead than they have ever handled before.

Representative PRICE. Within the next 15 years?

Mr. COOMBS. That is right; each year from now on for at least 15 to 20 years ahead. And in the case of schools, of course, this has already happened. The elementary schools have felt this tidal wave for better than 5 years. The high schools will begin to feel the impact within the next 2 years. The colleges are expanding their enrollments now, even prior to the time when they will feel the impact of these higher post war births, because the proportion of young people going to college is continuing to rise.

As I suggested, this is good. It is good that we have so many young people and that they want to get more education than their parents got. But the central issue is: Can our schools and colleges give this many young people a good quality education? Or will this rise in enrollments, coupled with a shortage of good teachers, force a steady deterioration of educational quality all along the line, at a time in history when our Nation needs better education, not worse?

That leads to the second question: How many teachers would we need?

Taking the next 10 years, in the case of elementary aid secondary schools—these are approximate figures—we now have about 1,200,000 schoolteachers in this country, including both public and private schools. We will need by 1965, to maintain the present pupil-teacher ratio in the schools, more than 1,600,000.

To expand our total staff of schoolteachers by this amount—and to replace the 8 to 10 percent who leave each year—we would have to recruit something on the order of 1,900,000 new teachers over the next 10 years. This is equivalent to 50 percent of all 4-year college graduates that can be expected to emerge from all our colleges and universities combined during the same 10-year period! In recent years only 20 percent of such graduates have entered schoolteaching.

In other words, if we were obliged to staff our schools entirely from new college graduates, one in every two college graduates of every kind, not only teacher-college graduates but engineers, journalists, and so forth, would have to go into our schools. Of course, there are some other sources of new teachers, particularly mothers and housewives who graduated from college some years ago, but they are not as large a source as the output of new college graduates and they cannot be relied upon to fill the gap.

At the college level, to maintain the present student-teacher ratio, we would need within 15 years or so to double the number of college teachers we now have, in addition to replacing those who retire, die, or are hired away by industry. Compared to about 190,000 college teachers on the job in 1954, we would need to recruit between 336,000 and 484,000 new college teachers during the next 15 years.

Now the usual standard of preparation for a good college teacher is the doctor of philosophy degree or its equivalent. There are, of

course, many good teachers without degrees of doctor of philosophy, and there are some rather poor ones with degrees of doctor of philosophy; but the proportion of college teachers with the doctor of philosophy degree is a useful rough index of the amount of preparation. Approximately 40 percent of all college teachers in the United States today have doctor of philosophy degrees. Projecting the likely output of doctors of philosophy over the next 15 to 20 years, and assuming that the colleges get something like their present share of the new doctors of philosophy (on the order of 50 to 60 percent), we find that by 1970, only 20 percent of all college teachers would be doctors of philosophy. This means that a college student in 1970 would have only half the chance that a college student now has of getting a teacher in college with the equivalent of a doctor of philosophy training.

The foregoing statistics carry some profoundly serious implications for the future of American education and for our whole society. No one has seriously challenged the validity of these figures, though certain professional educators have apparently been unhappy about some of the conclusions which the fund for the Advancement of Education drew from these figures.

We concluded that this teacher shortage—which is as much a problem of quality as quantity—cannot be solved on the present basis of recruitment, preparation, and utilization of teachers.

I will explain our further conclusions by returning to my prepared statement.

11. To avert the serious deterioration of quality in education that would result from this imbalance between the demand and supply of teachers, and to achieve improvement of quality instead, will require improvements in curriculum, in buildings and equipment, in guidance and counseling, and in other important aspects of the whole educational enterprise. But the most crucial requirement of all is to achieve a steady improvement in the quality of teaching. I believe we have enjoyed steady improvement in the quality of teaching, overall, for many generations. We have today a large number of excellent and dedicated teachers, a far larger number perhaps than whe have any right to expect, considering the way our Nation has allowed the teacher's economic and social status to erode over the years. In short, we have made good progress. But we should be concerned now with what the quality of teaching will be tomorrow. As things stand, the prospects are decidedly poor. Consequently the atomic energy industry and every other user of specialized talent in our society should be deeply concerned about tomorrow's supply of new talent for them. Without enough good teachers, and efficient use of them, we cannot hope to relieve the overall shortage of talent.

12. The problem in a nutshell is that our schools and colleges, in bidding for teachers in the brisk market for high caliber manpower today, have been at an increasing competitive disadvantage relative to business and government. Teachers' salaries have been going up recently, almost everywhere, and this is good; but so have other salaries. For example, raw college graduates are going forth this spring with bachelor of science degrees in science or engineering—including graduates who are no better than average in their class—into industrial jobs that pay more than the average salary received by the experienced college teachers who produced these graduates.

If this trend continues, if not enough of the ablest graduates return to education as teachers, then who will be turning out the bright young scientists and engineers for industry to hire 10 years from now?

What is happening in science and engineering is happening in other fields. Those who believe that progress in science needs to be balanced by progress in the humanistic arts and in the social sciences if we are to preserve a rich culture and a stable political life, and if we are to achieve a higher measure of individual fulfillment and dignity in our free society, those who believe this are profoundly worried today over the prospective drying up of the flow of talent into these non-science fields.

13. This teacher shortage problem—its qualitative side can be solved, I believe. But quite clearly it cannot be solved or even part way solved on the basis of existing policies, practices, and general conditions which govern the recruitment, preparation, and utilization of teachers. This is not the place to enter into a full discussion of what is required to solve the teacher shortage problem. It is obvious, however, that teaching at all levels must be made sufficiently attractive to enable our schools and colleges to command a larger share of the Nation's finest talent than is now possible. Making teaching that much more attractive will not be accomplished by higher salaries alone, though better salaries are obviously essential.

Not only must the general level of salaries be raised, but the salary structure itself must be overhauled to provide greater incentive and reward for outstanding individuals. This also implies a considerable change in how we use the talents of teachers, to the end that we can assign responsibilities and rewards to individual teachers in accordance with their particular talents and performance. It means, in short, that the teaching profession must adopt the same principles of division of labor that have made possible great strides and increasingly better utilization of specialized talent in all other major professions.

14. The foregoing observations add up in summary to the following:

(*a*) The shortage of scientists and engineers, of specialized talent for other fields, and the shortage of high quality teachers, are all parts of the same basic manpower problem. This problem arises from our rapid rate of progress in many fields, from the prosperity and steady growth of our economy, from our desire to continue such progress in the future, and only incidentally from the cold war.

(*b*) Short-run expedients to relieve the shortage of specialized talent in any one field, such as atomic energy, will not provide a long-range solution. Such a solution requires a frontal attack on the basic causes of the problem, which are to be found largely in our schools and colleges. It cannot be solved in pieces. It must be solved as a whole, which means expanding the total supply of specialized talent of all types for all purposes.

(*c*) The essence of such a broad solution is to develop more fully than we are now doing the latent talents of our young people, which in considerable measure is a job for our educational system. Along with this we must find ways to use more efficiently the best talent we have.

(*d*) At this particular time, however, our educational system is in a poor posture to accept this challenge to improve quality, for it is fully engaged in fighting off powerful forces of deterioration. Our

schools and colleges, faced with rapidly rising enrollments, have become the most serious victims of the overall shortage of specialized talent, and the situation promises to get worse. To identify talented young people at an early age and to nourish such ability toward full maturity requires teachers of the highest quality, operating under favorable conditions. There is a shortage of such teachers and it is growing rapidly worse.

(*e*) This being the situation, the most serious threat to our long-run national welfare and security is not today's shortage of scientists so much as today's and tomorrow's shortage of talented teachers. This is not to discount the high importance of achieving further rapid progress in the atomic energy field. It is rather to emphasize that we cannot sustain such progress there or anywhere else unless our schools and colleges are well tooled and staffed to turn out a steadily expanding flow of specialized talent of every variety.

15. If this is the essence of the problem we face, then what practical steps can be taken toward solving it?

The first step is to secure a broad public understanding of what the whole problem is and how important it is to everyone. This has not yet been done, to the best of my knowledge. This committee could render a great public service by taking this step. The present facts and future prospects need urgently to be presented to the whole Nation, by someone with a clear and convincing voice.

The second step, as suggested earlier, is to formulate and proclaim a comprehensive Federal policy with respect to the long-range development of specialized talent, not just a policy for science and engineering manpower—which at best would be a lopsided policy and hence perhaps even an injurious one—but a policy which calls for the fullest development of the Nation's finest human abilities in all directions. This does not mean that the Federal Government, having set forth such a policy, should alone assume responsibliity for implementing it. On the contrary, the bulk of the job must obviously be done by others. But the Federal Government is surely in the best position to exercise leadership, to guide and inspire, and where necessary to mobilize, the energies and imagination of the various agencies, public and private, whose combined efforts alone can meet the need.

The fact that each of us, in and out of government, tends to be preoccupied with more specialized problems, makes the formulation of such a comprehensive policy difficult. It seems to be no one's particular business. This difficulty is compounded by the fact that in some quarters the view still lingers that any special attention given to gifted students is somehow undemocratic, while in still other quarters the very notion of developing one's intellect through education has become the target of a virulent anti-intellectualism. All of this makes even more urgent a clear and bold expression of national policy on the matter. Surely by now the cold war, if not the hot one before it, has demonstrated that to survive and prosper a free society must develop as fully as possible its human resources, including its best brains. Judging from the Soviet Union's program of education, this appears to be viewed as a sensible policy even in a totalitarian society.

A third step toward improving the Nation's supply of specialized talent is to reduce the economic roadblocks that now discourage many young people of high ability from realizing their full potential. I am sure you have been informed before now that over half of the ablest

top quarter of our high school age young men and women do not go on to college. Economic inability is one of the important reasons. There are encouraging developments in this direction, such as the recently established national merit scholarship program and the expanded interest of private businesses in supporting scholarships.

Representative PRICE. Was that program formerly known as the national scholarship program?

Mr. COOMBS. No, sir; this has been known from the beginning—it is only a year old—as the national merit scholarship program.

Representative PRICE. Is that a Ford Foundation program?

Mr. COOMBS. It is supported jointly by the Ford Foundation and 2 or 3 other private foundations, plus private corporations. The Ford Foundations made a major initial grant, but with the expectation that support from other private sources would follow. I believe they are just in the process of announcing the first crop of winners, just over 500 students selected from all over America to receive 4-year scholarships. These efforts need to be broadened. It would be an appropriate and excellent thing, in my view—and I speak only for myself—if the Federal Government were to contribute financial support to merit programs of this sort, not primarily to increase their size, for I think that private sources can help to expand their size, but to symbolize the National Government's concern and leadership in this vital area.

By the same token we need to encourage more of our best college graduates to enter teaching, both school and college teaching, in part by removing the economic roadblocks to graduate training. An outstanding college graduate who wants to become a physicist or chemist or oil geologist stands an excellent chance of getting financial assistance all the way through graduate school if he needs it, but not so the equally promising graduate who wants to prepare himself for teaching high-school mathematics or college English. Again, there are encouraging developments in the field of privately financed fellowships, but the amount is far short of the need. It would seem appropriate here, too, for the Federal Government to contribute both moral and financial support to merit fellowship programs designed to encourage a greater flow of able young people into teaching. In all cases where the Federal Government contributed support for merit scholarships and fellowships it would be best, I believe, to leave the administration of such programs in competent and impartial private hands, as is done with the Fulbright awards.

A fourth thing we need, quickly and on a vast scale, is some bold and imaginative experimentation in our schools and colleges directed at raising the quality of education in face of the shortage of good teachers. We must learn how to relieve our well-qualified teachers of clerical and housekeeping duties—and free them to teach full time. We must learn how to broaden the effectiveness of our very finest teachers, of which there will never be enough to go around. Teacher aids, comparable to nurses aids, are one way to enable a regular teacher to teach more children, to teach them better, and to have more fun doing it. Television and films afford a promising way to extend the reach of our rarest teachers.

There are some very exciting and promising experiments under way around the country right now addressed to these very problems and

more are taking shape. There has yet to be made, however, a really bold and adequate experiment on one of the most inviting targets of all—the teaching of science and mathematics in our schools and colleges. The possibilities here are wonderful to contemplate.

What we need and need quickly is a long overdue technological revolution in our whole educational system—as profound as the changes prompted centuries ago by the invention of printing and the appearance of the book as an instrument of learning. Educators, being human, too, are naturally inclined to resist such changes. Like the rest of us, they prefer to cling to old and comfortable habits, and to look with deep suspicion upon new ways. They endorse the principle of experimentation and acknowledge the need for it, but they are prompt to criticize specific experiments. Here as elsewhere in our society, however, there are wise and imaginative people who recognize the need and who are beginning to blaze new trails. As the facts of our situation become better known, and especially as lay citizens express their concern and support, we can expect our schools and colleges to taskle this problem with increasing boldness and imagination.

There are many other steps that must be taken, not simply by the Federal Government but especially by the schools and colleges, with the encouragement and support of State goverments and local communities, private organizations and others. The machinery for action on all these fronts exists for the most part; it needs mainly to be set in rapid motion. Federal funds have a role to play, but the greatest need is for vigorous Federal leadership which will place this urgent problem in public perspective and induce positive action in many quarters. I feel sure these hearings will help in this direction.

Representative PRICE. Thank you, Mr. Coombs. The committee is certainly hopeful that the hearings will be helpful. We realize, as everyone does, there have been many warnings sounded by people who are close to this problem, and warnings have been sounded for several years. As you say in your statement, the warnings are sounded but nothing is done about it. The problem is trying to do something about it.

Federal leadership is required, and there is also great cooperation necessary on the part of nongovernmental groups. We have many such groups in the country. It appears from the statements that have been made here they are all trying to do something about it.

It may be through this general forum that we have provided in the committee hearings and through the recommendations being laid out over the table during the hearings that we can arrive at a single program of governmental and nongovernmental agencies cooperating to adequately alert the country to the need of a sustained and lasting program to produce the scientific and engineering manpower our country will require and to bolster our educational system in general.

Mr. COOMBS. If I may, Mr. Chairman, I would illustrate one precise way in which I think some clear Federal leadership would unleash a great many energies at the local level.

There are many teachers, many principals, many parents in our various communities who believe—and I think correctly—that our schools in many cases are not providing adequate programs for their ablest students; but they are afraid oftentimes to advocate a program for able students lest it seem like a kind of highbrow thing, lest it

be called undemocratic. It is positively unpopular in many quarters to advocate such programs.

If the Federal Government itself would advocate such programs to be taken on at the local level, it seems to me it would free these people to do what they want to do and give them the kind of support in their own community that would help.

This is but one example of what a clear pronouncement of Federal policy here would do, I think.

Representative PRICE. Thank you very much, Mr. Coombs, for your very able and fine presentation. The committee appreciates your courtesy in appearing here and the time you have given to this subject.

Mr. COOMBS. Thank you for the opportunity, sir.

Representative PRICE. The next witness will be Dr. Eli Ginzberg, National Manpower Council. You may proceed, Doctor.

STATEMENT OF ELI GINZBERG, PROFESSOR OF ECONOMICS, GRADUATE SCHOOL OF BUSINESS, COLUMBIA UNIVERSITY

Mr. GINZBERG. Thank you, Mr. Chairman.

Representative PRICE. I see you have a prepared statement.

Mr. GINZBERG. I am going to talk, if I may, a little bit more freely from an outline, but the statement contains points I plan to make.

Could I identify myself in a different capacity as far as my presentation here this morning?

I am professor of economics at the Graduate School of Business, Columbia University, and director of the Conservation of Human Resources. It is true that I am also the Director of Staff Studies of the National Manpower Council, but I am not appearing here this morning in the latter capacity because you have received from the Chairman of the Council, Mr. James D. Zellerbach, a long written memorandum about the position of the Council as it has been developed over a period of 5 years.

Representative PRICE. That is correct. At this point, without objection this material which we received from Mr. Zellerbach will be included as part of the record.

(The material referred to follows:)

STATEMENT SUBMITTED BY JAMES D. ZELLERBACH, CHAIRMAN, NATIONAL MANPOWER COUNCIL

APPROACHES TO MANPOWER PROBLEMS

1. The concept of manpower shortages

"Some authorities assert that there is little to be gained by trying to assess the extent of existing shortages in quantitative terms. They maintain that quality is the key factor in the demand for and the supply of scientific and professional personnel. For this reason the American Chemical Society, for example, has called attention to the unmet demand for various kinds of competent chemists, but it has not attempted to estimate the size of the current shortage.

"In the case of physicists, too, there is little point in estimating the size of the shortage. Because of their great importance for national security, even a relatively small shortage of physicists is particularly critical. For some time, mature leaders for research projects as well as creative research physicists have been in particularly high demand.

"To contribute to the making of sound policies for relieving present and preventing future shortages, the National Manpower Council sought to learn how current shortages arose and to develop criteria for evaluating their significance. To accomplish this purpose, the Council, with the assistance of the staffs of

professional societies and of other experts, undertook detailed studies of three groups of professionals—engineers, teachers, and physicians—and one group of scientists—physicists.

"It is easy to demonstrate the existence of shortages, if the term is defined as the inability of employers to secure all the additional qualified personnel they are willing to hire at prevailing salary levels. It is far more difficult to determine the causes and full significance of shortages and their remedies. The basic information concerning the demand for and the supply and utilization of scientific and professional personnel is grossly inadequate, and a theoretical framework for the analysis of manpower problems still remains to be developed.

"The emergency created by Communist aggression in Korea provides the key to many current shortages. The ensuing very sudden increases in expenditures for defense production and research and development came at a time of high civilian employment. These increases were quickly reflected in additional demands for scientists and engineers. However, the supply of scientists and engineers available to meet the new and expanding demands of industry and Government was reduced after mid-1950. The peak college graduating classes of the postwar years were over; the draft had been reinstituted; and the armed services were forced to recall a large number of reservists.

"Many employers, apprehensive about the future availability of highly trained personnel, hired engineers and scientists with an eye to anticipated rather than actual requirements. The tax structure and the cost-plus provision in Government contracts encouraged employers to be uneconomical in the employment and utilization of manpower.

'Since 1950, moreover, the United States has sought to have both more defense and more goods. In contrast to World War II, when the output of goods for civilian use was curtailed, civilian output since Korea has actually increased. Under these conditions, there has been a high demand for all kinds of physical and human resources. As the supply of highly trained manpower cannot be expanded quickly, these sudden and large increases in demand inevitably resulted in shortages.

"A particularly important factor in the heavy demand for scientific and technological manpower has been the sharp rise in expenditures for research and development purposes. These expenditures doubled between 1949 and 1952. Current research and development projects, employing about 160,000 scientists and engineers, represent an annual cost of about $3.5 billion. The Federal Government provides three-fifths of this money, most of which is being spent on applied research and development for defense purposes, and not on the basic research which aims at extending scientific knowledge.

"The current high demand for physicists, chemists, and other scientists, however, cannot be attributed solely to the sudden expansion in research and development activities for defense. One consequence of the enormous strides taken in nuclear physics, electronics, and other fields in recent years has been the establishment of a higher demand for scientific personnel by industry. Private industrial research, moreover, has been steadily growing in importance for several decades. Just as technological progress has led to the greater use of engineers, so the practical application of scientific discoveries has increased the use of scientists by industry.

"In this period of partial mobilization, the United States has resorted to a minimum of governmental control over manpower and has made limited use of priorities for the allocation of other scarce resources. As a result, the difficulties of transferring required resources to defense purposes have been multiplied. In the absence of a system of governmental controls and priorities, it has been both possible and profitable for industry to continue to stress production for the civilian market, with the result that there has been some delay in achieving defense goals.

"Unlike the current shortages of engineers and scientists, those of teachers and physicians are not primarily the result of demands produced by superimposing a program of partial mobilization upon a civilian economy operating at a high level of employment.

"Shortages of qualified elementary-school teachers have been a continuing problem since World War II, when many teachers left their posts for military service or for better paying jobs in industry. For more than a decade, attractive opportunities in private industry and the relatively low salaries and prestige of teachers have discouraged many from entering or continuing in the profesison. Few communities have been sufficiently farsighted or resourceful to protect their supply of competent teachers. The total number of qualified teachers

available is influenced by the steady rise in standards of licensing and by the fact that 90 percent of the elementary-school teachers are women. Many women view teaching as a temporary occupation before marriage rather than as a lifetime career. The demand for teachers has been affected by the sharp rise in births during the 1940's, which is now reflected in increased elementary-school enrollments and is beginning to be felt at the high-school level. The spectacular population growth of new industrial and suburban areas has also created unusual demands for teachers in many communities.

"Higher standards of health and a growing national income have increased the demand for medical service. At the same time, the limited capacities and the admission requirements of the medical schools have restricted the total number of doctors trained each year. Moreover, the supply of qualified physicians has been unevenly distributed throughout the country. For economic and other reasons, medical practice in rural areas has long been relatively unattractive. Although the ratio of doctors to population does not provide an accurate measure of medical care, it is significant that in 1949 there was 1 physician to about 500 people in the State of New York and 1 to almost 1,600 in Mississippi. The fact that 13,000 physicians—7 percent of the total supply—are in the Armed Forces also contributes to the current shortage of doctors.

"Certain manpower shortages are the inevitable reflections of scientific discovery and technological change. For example, recent advances have resulted in a shortage of solid-state physicists. Young men and women cannot be specifically trained for fields of work which may open up in the future. The scope and quality of their education and work experience, however, can prepare them to convert their skills to work on problems in new fields. Such convertibility provides in effect a potential reserve that can be drawn upon to meet demands for new kinds of personnel.

"Demands for scientific and professional manpower can fluctuate sharply and unpredictably. The size of the supply, however, can be modified only slowly. Young men and women make decisions about their future careers in terms of life plans. Preparation for scientific and professional work requires many years of education and training. Within any limited time period, therefore, the demand for scientific and professional personnel is subject to far greater variations than the supply. There is real danger, consequently, in estimating future manpower requirements on the basis of current shortages or surpluses. Immediately before the outbreak of hostilities in Korea, the graduating classes of engineering schools were much larger than normal. In the light of the industrial demand then existing for engineers, many experts feared that some of the 50,000 engineering graduates in the record class of 1950 would find it difficult to secure satisfactory employment. After the Communist aggression in Korea, however, the possibility of a surplus of engineers was replaced by the actuality of a shortage." (From the Council's statement, A Policy for Scientific and Professional Manpower, pp. 10–14, 15, 17.)

(See also, A Policy for Scientific and Professional Manpower, Ch. VII, "The Nature of Manpower Shortages," and Chs. VIII, IX, and X passim; Proceedings of a Conference on the Utilization of Scientific and Professional Manpower, pp. 69–70, 147–149, 169–171, 177–178, 184–186.)

2. Issues of quantity and quality

"Shortages of scientific and professional manpower always have qualitative as well as quantitative aspects. While some shortages involve an unfilled demand for hundreds or thousands of qualified personnel, others consist in the lack of a few individuals who possess rare and unusual qualities. Consequently, an increase in the gross supply alone may provide no solution for a specific shortage. Two second-rate engineers are not a substitute for the one first-rate man required. The addition of ten mediocre teachers to the staff will not relieve a school's need for several inspiring instructors. More general practitioners in a community do not make up for the lack of a competent neuro-surgeon or psychiatrist. The fact that all fields can always benefit from the work of men of outstanding ability underlines the limitations of considering scientific and professional manpower shortages solely as a problem in numbers." (From the Council's statment, A Policy for Scientific and Professional Manpower, pp. 15–16.)

(See also, A Policy for Scientific and Profesional Manpower, pp. 181–182; Proceedings of a Conference on the Utilization of Scientific and Professional Manpower, pp. 134–136, 152–154.)

3. Interdependence among different manpower groups

"Training in the physical sciences, engineering, or medicine has an obvious and immediate importance in a period of partial mobilization. Yet, it is folly to believe that only these specialties add strength to the Nation. The accountant, the social worker, the lawyer, the soil conservationist, the minister, the economist, and many other trained persons contribute significantly to the security of the Nation. For security is based on political, moral, and economic strength as well as armed might.

"In the 1930's, the study of nuclear physics, Russian history, or Arabic culture was looked upon as thoroughly impractical. Today, specialists in these fields are eagerly sought. To channel students into fields where shortages now exist, and thus rob the Nation of other specialists who may be needed tomorrow, would be a mistake." (From the Council's statement, Student Deferment and National Manpower Policy, pp. 9–10.)

"Some shortages of scientific and professional personnel have been alleviated by improvements in the utilization of manpower which have had the effect of stretching the existing supply. Thus, auxiliary workers have been employed to relieve qualified engineers from routine tasks so that they can perform at a higher level of skill. For practical purposes, this change in utilization practice is equivalent to expanding the supply of engineers. The use of emergency licenses increases the available supply of teachers, although it may be criticized for sacrificing quality for quantity.

"Manpower is never the only factor required for the production of goods, services, and ideas. It is necessary to determine for each shortage how limitations in personnel are related to other factors required to increase output. In addition to a shortage of scientists, for example, there may also be in a specific situation a shortage of capital, facilities, strategic materials, or technical workers. If such other shortages exist, it might be impossible to increase output even if additional scientific manpower were available. Thus, the scale of research and development activities is limited not only by the supply of scientists and engineers, but also by the willingness and ability of civilian industry and the Armed Forces to finance the production of new items in light of large investments in existing processes and stocks of finished goods." (From the Council's statement, A Policy for Scientific and Professional Manpower, pp. 14–15.)

"We are sometimes likely to forget that the rate of our economic progress depends in considerable measure on the quantity and quality of our available skilled manpower. Many small, but important, improvements in technology are made by skilled and technical workers. Moreover, the rapidity with which major innovations can be introduced into the economy depends in part upon the availability of skilled manpower. This is no less true for the armed services than it is for the civilian sector of the economy. Shortages of skilled manpower can retard economic progress, and there are limits to the extent to which additional machines can be used as substitutes for skilled workers and technicians. Many difficulties that underdeveloped countries experience in trying to improve their economic position, even when they have enough capital, arise from inadequate numbers of supervisory and skilled personnel. Even in the United States the inter-relations between skilled manpower and the economic progress can be seen in the problems encountered in speeding the industrialization of the South, or in attracting new industries to such areas as the anthracite coal mining counties of Pennsylvania." (From the Council's statement, A Policy for Skilled Manpower, pp. 17–18).

(See also, Proceedings of a Conference on the Utilization of Scientific and Professional Manpower, pp. 49–51, 63–64, 81–83, 125, 185; A Policy for Skilled Manpower, pp. 44, 51, 57–60, 76–78, 87–88, 284.)

BROAD OBJECTIVES OF MANPOWER POLICY

1. Expanding the overall supply of highly trained manpower

"Scientists and professional persons cannot be stockpiled like commodities against future shortages or hastily trained in response to sudden surges in demand. The problem of preventing future shortages, therefore, raises the question of what methods are available to a democratic society to insure a reasonable balance between supply and demand. Several factors that exercise major influence on supply and demand are not amenable to direct control by a free society. These include the dynamic character of modern science and technology, the expansion and contraction of the economy, irregularities in the birth rate,

changes in educational institutions, and the values which affect the career decisions of individuals.

"The Nation can follow two broad courses of action in attempting to prevent future shortages:

> "We can try to alter the distribution of young men and women among fields of scientific and professional study so as to increase the numbers preparing for work in fields where shortages are anticipated; and
>
> "We can try to expand the size of the total college population so that more young men and women of ability will be educated and trained in each field.

"Efforts are now being made to induce more students to select careers in fields where continuing shortages are expected, such as engineering, physics, chemistry, industrial management, and teaching. When energetically pursued, this course of action has the advantage of producing results in a relatively short time by influencing the career decisions of students about to enter or already in college. But, if the total college population remains stable, altering the distribution of students among fields of specialization means the growth of some fields at the expense of others. Thus, engineering may gain at the expense of chemistry, or physics at the expense of mathematics. If able students are channeled into scientific and technological fields, the social sciences and the humanities will inevitably suffer." (From the Council's statement, A Policy for Scientific and Professional Manpower, pp. 17–18.)

(See also, Student Deferment and National Manpower Policy, pp. 81, 89–91; A Policy for Scientific and Professional Manpower, pp. 32–37; A Policy for Skilled Manpower, Ch. III and pp. 37–39, 57–60, 133–135; Improving the Work Skills of the Nation, pp. 10, 12–14.)

2. The development of high ability potential

"Today, less than half of those capable of acquiring a college degree enter college. About two-fifths of those who start college—many with superior ability—do not graduate. For every high school graduate who eventually earns a doctorate degree, there are 25 others who have the intellectual ability to achieve that degree but do not.

"Because there are so many more young men and women in the Nation capable of profiting from higher education than are currently obtaining it, future shortages can be guarded against by increasing the proportion of young men and women who graduate from college. An increase in the number of college graduates would expand the source of supply from which the Nation's scientists and professional persons come and would help to reduce the loss represented by the failure to train many able individuals.

"Three groups can readily be identified in the reserve of individuals capable of pursuing advanced education: high school graduates who do not enter college, those who start college but do not graduate, and those who graduate but do not pursue postgraduate training. There is an additional hidden reserve made up of capable individuals who achieve low scores on standard tests of intellectual ability primarily because of serious deficiencies in their early schooling. These individuals live, for the most part, in poor communities which spend little on education, and are found particularly among such racial and ethnic minorities as Negroes and Spanish-speaking Americans. The barriers which limit the educational and occupational opportunities of these groups have been substantially reduced in recent years. Many Negroes, however, are still handicapped by poor education in early life, and others are frequently prevented from using the skills they do acquire by discriminatory employment practices." (From the Council's statement, A Policy for Scientific and Professional Manpower, pp. 19–20.)

(See also, Student Deferment and National Manpower Policy, pp. 16–18; A Policy for Scientific and Professional Manpower, ch. IV, The Potential for Higher Education; Proceedings of a Conference on The Utilization of Scientific and Professional Manpower, pp. 77–78; Improving the Work Skills of the Nation, ch. III, pp. 86–88.)

3. Maintenance of democratic values, including individual freedom of educational and occupational choice

"In a democratic society, the individual decides for himself the kind of education and career he will pursue. Since they determine the individual's future life, career choices should grow out of long-range considerations. Many students decide upon their careers quite early, sometimes before graduationfrom high

school. Others make their choice during the first 2 years of college. Wise counseling and reliable information can contribute to sound educational and career choices. Hasty and uninformed decisions result in serious wastes of the individual's abilities and of the community's resources. These considerations point to the serious responsibilities assumed by schools, professional societies, employers, and others when they make special efforts to induce young men and women to select particular fields of study." (From the Council's Statement, A Policy for Scientific and Professional Manpower, pp. 18–19.)

"In a democracy, compulsory military service should be as universal as possible. This principle would be fully observed if every man were inducted into the Armed Forces when he reached a specified age, such as eighteen and a half, without regard to his training, occupation, or responsibilities. But the rigid application of such a rule could endanger the Nation's security. Even under full mobilization in World War II, it was necessary to permit certain men to defer their military service.

"Deferments are greanted because of their value to the Nation, not as favors to individuals. In this period of partial mobilization, the country's manpower is adequate to meet the requirements of the Armed Forces and to permit the postponement of the military service of certain men. However, if the principle of universal service is to be realized, it is imperative that men who are deferred fulfill their obligation eventually and serve in the Armed Forces." (From the Council's statement, Student Deferment and National Manpower Policy, pp. 7–8.)

(See also, Student Deferment and National Manpower Policy, ch. VI, and pp. 11–12; Proceedings of a Conference on the Utilization of Scientific and Professional Manpower, pp. 7, 9–12, 26–29, 79, 108; Improving the Work Skills of the Nation, pp. 169–170.)

4. Importance of basic and long-run related policies.

"There is no magic formula for the relief of manpower shortages. Each shortage requires separate analysis in order to determine how it can best be alleviated. Imbalances between supply and demand result from various causes and call for different kinds of corrective action." (From the Council's Statement, A Policy for Scientic and Professional Manpower, p. 14.)

"Our future progress and strength depend upon a conscious and deliberate concern with our manpower resources. Recognition that our most precious single resource consists of the skills, capacities, and creativeness of our people is not enough. For the sake of contributing to the greater well-being of each individual and strengthening the nation as a whole, it is also necessary for us to assure the further development of our manpower resources and their more effective utilization. To take such action we must view our human resources as a whole, and not only as they now are, but as they can be developed.

"In the past we have acted as if each manpower problem exists in isolation—whether it be the waste of potential ability and talent, shortages of teachers and nurses, or the adequacy of a community's facilities for training technicians. Consequently, we are easily diverted from a search for sound solutions for complex and difficult problems and tend to rely upon simple and short-sighted answers." (From the Council's statement, A Policy for Skilled Manpower, p. 19.)

(See also, A Policy for Scientific and Professional Manpower, ch. XII; Proceedings of a Conference on the Utilization of Scientific and Professional Manpower, pp. 4–8, 91–92, A Policy for Skilled Manpower, ch. XI, pp. 37–41.)

LINES OF ACTION

1. Strengthening all educational institutions

"Our colleges and universities are the training centers for the Nation's scientific and professional manpower. A decline in the quality of their teaching and research staffs or in other resources necessary for the effective performance of this function would injure the Nation irreparably. At the end of 1952, the Commission on Financing Higher Education reported a growing and serious discrepancy between the resources available to institutions of higher education and the costs of the services they are expected to perform.

"In recent years the colleges and universities have seen effective teachers and gifted research personnel drawn away by the higher salary scales of industry and Government. More important, low salaries are discouraging promising young men from entering upon academic careers.

"Some relief from the financial problems faced by colleges and universities, particularly in the case of the larger institutions, is provided by their research and development contracts with the Federal Government and industry. These contracts, in addition to the contributing to the improved security of the country, have enabled many institutions to expand their staffs and research facilities.

"But there is a serious danger that large-scale contracts for applied research may ultimately deflect the colleges and universities from their primary responsibilities for basic research and teaching. If basic research and teaching are neglected, the education of undergraduate and particularly of graduate students must suffer. The heavy emphasis of contract research on the natural sciences also reduces the relative importance of the social sciences and the humanities within the university structure.

"Reporting in March 1953, the committee on institutional research policy of the American Council on Education pointed out that 'both Government and higher education have a special obligation to continue a sound program of basic research. * * * This is a function of funds, of emphasis, of environment, and of men. This is another way of saying that it is a problem of maintaining the academic integrity of our educational institutions, of adhering to the primary objectives of higher education, and of not being beguiled by the temporary attractiveness of sponsored research that does not meet these long-term objectives.' The staff of the National Science Foundation is now studying the impact of Federal funds for scientific research on the institutions of higher education.

"The National Manpower Council recommends that:

> "1. State and local governments, alumni, business, labor, and other interested groups and individuals intensify their efforts to provide the financial support required by the colleges and universities to improve their faculties and facilities.
>
> "2. The President appoint a commission composed of representatives of Government, universities, and industry to review the impact of governmental research and development contracts upon the primary responsibilities of the colleges and universities to advance fundamental knowledge and train tomorrow's scholars and scientists.
>
> "3. Colleges and universities recognize that a dynamic society requires the kind of education and training that equips students to meet not only the demands of their first jobs but also the challenges of new tasks and problems which they will face many years later."

(From the Council's statement, A Policy for Scientific and Professional Manpower, pp. 22–24.)

"One of the most important developments in American life has been the remarkable growth in secondary education. Few boys and girls went to high school in 1900. Today, 4 out of 5 young people receive some secondary schooling, and 3 out of 5 graduate from high school. About 8 million boys and girls are now enrolled as daytime students in some 24,000 public secondary schools. We are now entering upon another period of rapid growth, and it is expected that by 1965 our publicly supported secondary schools will have about 12 million daytime students—an increase of 50 percent over the present enrollment. In the next few years, therefore, we will be setting the pattern for secondary education for a period of expansion.

"Secondary education seeks to prepare our youth for assuming the privileges and responsibilities of citizenship and for leading a meaningful and worthwhile life. It fulfills another key purpose by helping to prepare them for work, both those who continue with their formal schooling and those who enter employment immediately upon leaving high school. Preparation for work is an integral part of secondary education because high school provides all students with an opportunity to increase the skills which form the foundation for work. These skills consist of the ability to communicate effectively in writing and speech, to handle elementary mathematical operations, and to utilize knowledge to cope thoughtfully with problems. From his school experience, moreover, the student acquires basic work habits. He learns to follow a regular schedule, to meet performance standards, and to respond to incentives in the form of grades, privileges, awards, and opportunities for further study.

"Preparation for citizenship, for the growth of the individual, and for work are related and complementary purposes of secondary education. They are not in conflict with one another or even in competition although the debates that engage educational leaders sometimes suggest that they are. The secondary schools can make their maximum contribution to the development of the

Nation's manpower resources by insuring that their students are equipped to communicate effectively, to do mathematical operations, and to respond thoughtfully to problem situations, for without these basic skills the abilities and competence required for skilled and technical work cannot be acquired.

"The positive value that Americans assign to education and the practical benefits which the individual derives from formal schooling have combined to keep more of our young people in school longer. High-school graduation is increasingly becoming a qualification for desirable employment, and the Armed Forces urge young people to complete high school before beginning their military service. High school graduation is not only a prerequisite for advanced schooling but it is also extremely important in securing access to the opportunities for acquiring skill in industry and the armed services.

"Throughout the country, communities are critically evaluating the education of their children. This is a healthy development. In the past we have been more preoccupied with school buildings and the number of years our children spend in school than with the quality of their education. We are just beginning to understand the difficult tasks that face the high schools of the country because their student bodies comprise boys and girls who vary greatly in family background, intellectual ability, motivation, and educational need. More by accident than conscious design we have required the schools to assume responsibilities for the development of our children which lie beyond the reach of their limited funds and teaching resources. We are beginning to recognize that as citizens we must provide more financial support if we want the schools to do a tolerable, let alone a superior, job in accomplishing their major educational tasks.

"The key to good education is good teaching. When able men and women are discouraged from entering upon a teaching career or leave after a few years because of poor salaries and low prestige, it becomes extremely difficult for the Nation to realize its educational goals. Exceptional teachers are always at a premium and the schools face no greater challenge than to learn how to make the most effective use of those they have. In concentrating attention on the problem of shortages of teachers we have neglected developing more effective ways of utilizing our available teaching personnel. The need to recruit and maintain an adequate number of competent high-school teachers of mathematics and the physical sciences deserves special comment. Lack of instruction or poor instruction in these subjects can cut off many boys and girls from opportunities to prepare properly for skilled and technical occupations.

"During the past three decades vocational education has secured an established place within secondary education. Vocational schools and courses are not designed to produce fully trained skilled workers and technicians. They do, however, aim to provide young people with the fundamentals of specific occupations and to prepare them to acquire further skills more readily either on the job or through additional schooling. As the proportion of young people attending high school increased and as the school-leaving age rose, vocational education sought to meet the occupational needs of many who did not plan to go to college. Since 1917, Federal funds, matched and exceeded by State and local appropriations, have spurred the growth of vocational education, while Federal law and administrative practice have influenced its forms and objectives.

"Although general and vocational education are intermingled in the same school systems, sharp differences still exist between educational leaders in the two fields. In some States and communities these differences are intensified by separate administrative structures for vocational education. Partly because of the size and diversity of the high-school population, the separation of vocational education from general secondary education is becoming less distinct. The number of separate vocational high schools is relatively small, and vocational instruction has been diffused throughout the secondary school system. Four-fifths of the 2,000 high schools offering trade and industrial vocational courses under the Federal-State program are not vocational schools. Federally supported vocational agriculture courses are offered in 10,000 high schools. In addition, many high-school students are enrolled in industrial arts and business courses which lie outside the Federal-State program.

"To make certain that vocational education is fully responsive to changes in technology and to the ways in which skilled and technical manpower resources are developed in the United States, it is necessary to guard against certain errors which have been made in the past. One of these errors is to conceive of vocational courses as a means of preparing students for specific jobs rather than as providing them with a broad base for later training. A second is to relate the vocational instruction provided in school solely to the needs of one or two

major employers in the community, or to traditional occupations, thus neglecting new fields of work. A third error is to direct less able and poorly motivated students into vocational courses on the ground that their educational needs cannot be met in any other way. A fourth lies in failing to provide vocational, as well as general, high-school students with as much mastery over the basic mental skills as they are capable of acquiring. And a fifth error is to compel vocational students to pursue programs of study which severely reduce their opportunity of going on to college, if they later decide to do so.

"In order to strengthen the contributions of secondary education to the development of our resources of skilled workers and technicians, the National Manpower Council recommends that—

"1. Local and State governments encourage men and women of ability to enter and remain in the teaching profession by establishing more desirable conditions of employment, including salaries commensurate with their training and responsibilities.

"2. Boards of education and school officials concentrate on achieving the key purposes of secondary education—to prepare the individual for citizenship, for a worthwhile life, and for work—by insuring that all students, excepting the small minority unable to profit from it, pursue a common program at least through the second year of high school which concentrates on teaching them to communicate effectively in writing and speech, to handle elementary mathematical operations, and to apply their knowledge to solving the problems they will encounter in life and work.

"3. Boards of education and school officials insure that students are permitted to specialize intensively in vocational subjects only after they have completed 2 years of high school, and that able and interested vocational students also are provided with the opportunity to qualify for college entrance.

"4. Local and State educational officials, in cooperation with special advisory committees comprising employer and labor representatives, critically reappraise existing vocational education programs in order to insure their effectiveness in the light of current changes in technology, employment standards, and on-the-job training practices; the growth of junior and community colleges and technical institutes; and the training programs of the armed services.

"5. The Congress review existing Federal legislation providing grants-in-aid for vocational education purposes in order to ascertain whether the objectives, scale, and methods of allocation of funds are enabling the Federal government to make the most effective contribution to the development of the Nation's resources of skilled manpower."

(From the council's statement, A Policy for Skilled Manpower, pp. 20–25.)

(See also, Student Deferment and National Manpower Policy, pp. 73–78; A Policy for Scientific and Professional Manpower, ch. X, pp. 109–112, 247–250; Proceedings of a Conference on the Utilization of Scientific and Professional Manpower, ch. VII, pp. 83–86, 96, 99–101, 179, 182–183; A Policy for Skilled Manpower, ch. V, VI, pp. 39–42, 109–114, 288–290; Improving the Work Skills of the Nation, ch. III, V, XI, pp. 5, 11, 95, 156, 184–185.)

2. Improving educational and occupational guidance

"The freedom of the individual to choose his occupation and work is an article of American faith. In a complex, highly specialized, and changing society, the individual needs help to make effective use of this freedom. Particularly during their high-school years young people need assistance to clarify their understanding of their aptitudes, interests, and vocational goals; to learn about the range of occupations, not only in their own but in other communities; to relate their present schooling to their future work and career; and to become informed about the opportunities for further education and training. When a person makes an educational or occupational decision without due consideration of his strengths and his opportunities, he wastes his potential abilities, and the community's manpower resources are correspondingly weakened.

"Shortly after the turn of the century, a few secondary schools undertook to provide their students with vocational guidance. Today, vocational guidance and counseling are recognized as important functions of the secondary school. Yet, except for a small number of communities, these functions are not being satisfactorily performed. Most students do not receive the assistance they require to make the best educational and occupational decisions. Some counselors bas

their advice solely on the results of intelligence or aptitude tests. In some schools counselors seek to persuade their students to reach a particular decision rather than to help them make their own. The occupational information essential for sound vocational guidance is limited, and, moreover, it is frequently in a form that makes it difficult for the counselor as well as the student to use.

"In recent years many schools have vastly extended the scope of their guidance responsibilities by broadening their objectives to include the counseling of students on problems of personal adjustment. Neither funds nor personnel are available to enable most schools to achieve these objectives. At present there are about 18,000 persons in the junior and senior high schools who perform counseling duties for a school population of 8 million. Only a small minority are full-time counselors specially trained for their tasks. Until more and better trained personnel become available, it is important for the schools to reconsider the nature of their counseling commitments.

"The test of an effective program of vocational guidance lies in the success it has in helping the individual to take full advantage of the opportunities available to him—in short, to increase his true freedom of choice. Information presented in usable form that extends the occupational horizons of boys and girls, gives them a sense of the characteristics and future prospects of different occupational fields, and indicates the preparation required to enter them is basic for an effective guidance program.

"Many agencies play important roles in vocational guidance, but the secondary school is in a strategic position to affect the largest number of young people during crucial years of their lives. The school can help the student understand the importance of his educational and occupational choices by having the teacher provide relevant knowledge as a part of regular classroom instruction. In achieving this end, the schools will have to utilize their professional trained guidance experts to advise, assist, and support the classroom teacher, who will have to carry most guidance responsibilities. School officials, moreover, can encourage employers, unions, governmental officials, and others in the community to cooperate in the reparation and presentation of current occupational information.

"In order to develop a more effective program for vocational guidance in the schools, the National Manpower Council recommends that:

"1. State and local governments and boards of education recognize that the provision of essential educational and vocational guidance services is a major responsibility of secondary education by increasing substantially and rapidly the funds and staff available for guidance and counseling purposes

"2. School officials use their guidance and counseling staff primarily for vocational guidance purposes and, when expanded resources of staff and funds permit, also for counseling students with personal adjustment problems

"3. School officials make vocational guidance available no later than the ninth year and have it continue throughout the high-school course, and that they assign to the classroom teacher major responsibility for helping the student to make sound educational and occupational decisions

"4. School officials take the lead in their communities to assure a vigorous cooperative effort, in which industry, business, labor, government, the armed services, and civic groups participate, to provide occupational information and other types of assistance essential for effective vocational guidance."

(From the Council's statement, A Policy for Skilled Manpower, pp. 25–27.)

(See also, A Policy for Scientific and Professional Manpower, pp. 68–71, 91; Proceedings of a Conference on the Utilization of Scientific and Professional Manpower, pp. 69, 73, 77, 78, 79; A Policy for Skilled Manpower, ch. X; Improving the Work Skills of the Nation, chs. IV, XII, pp. 11, 17, 64–69, 187–191.)

3. Expansion of opportunities for education, training, and employment

"In recent years, the United States had been spending less than 1 percent of its national income on higher education. We spend about 2 percent of our national income on elementary- and high-school education. In contrast, we spend more than 4 percent on recreation. The Nation has the economic resources and the reserves of intellectually capable young men and women to increase its college-educated population and thereby to provide for an expansion of its scientific and professional manpower. We have the need and the means, but we must develop the understanding and the will to attack the problem.

"To encourage more able young men and women who do not now undertake advanced education and training to do so will require the accomplishment of at least the following four objectives:

"Increased opportunities for and marked improvement in the quality of elementary and secondary schooling so as to eliminate gross educational deficiencies where they now exist.

"The reduction of financial barriers which currently prevent able persons from attending college and pursuing postgraduate work.

"The determination of the constructive measures that must be taken to insure that a larger percentage of able college students graduate from college.

"The creation of a more favorable climate of opinion for intellectual work and the reward of intellectual achievement.

"These goals will not be quickly attained, but they can be realized if the Nation has the will to do so. The work of many local and State groups and such national organizations as the National Citizens Commission for Public Schools has helped to impress upon the country that it has not matched its professed belief in education with deeds.

"Considerable progress toward these objectives has already been made in recent years. Discriminatory barriers have been reduced. Scholarship and fellowship programs and veterans' benefits have made it possible for many able young persons, who otherwise would have lacked the means, to attend college and graduate school. A constantly larger number of business corporations and some trade unions have made funds available for scholarships. The foundations, which have long played a key role in the development of scientific and professional manpower, support a large number of specialized training programs. In creating the National Science Foundation in 1950, Congress recognized the importance of providing governmental assistance for advanced education and training in the physical, biological, and medical sciences.

"To expand the opportunitis for capable young persons to secure a higher education, the National Manpower Council recommends that:

"1. The public and its elected officials fulfill their responsibility to maintain good elementary and secondary schools by providing the financial and personnel resources necessary to remedy the present weaknesses in our educational system.

"2. The schools, professional societies, governmental agencies and other interested groups act together to strengthen the information and counseling services for high-school and college students to assist them in the sound selection of schools, courses of instruction, and careers.

"3. Scholarship and fellowship programs, supported by private and public funds, be maintained and expanded to help more young people of ability to acquire a higher education."

(From the Council's statement, A Policy for Scientific and Professional Manpower, pp. 25–27.)

"To restrict opportunities for education and training on the basis of an individual's race, religion, ethnic origin, or sex violates American ideals. It also wastes the potential abilities of a significant proportion of our total population, and thereby prevents the full development and effective utilization of the Nation's manpower resources. In recent years, major advances have been scored in reducing or entirely removing artificial barriers that limit the opportunities of members of minority groups to acquire a sound education or to secure training for employment as skilled workers. These gains have come about as a result of such diverse reasons as the quickening of the American conscience, the manpower needs of the armed services, and the maintenance of high levels of employment. Various voluntary groups, as well as several State and city governments and the Federal Government, have taken the lead in breaking down artifficial barriers to education and employment.

"The greater the demand on the Nation's available manpower resources, the more willing we have been to modify and even abandon traditional practices which place certain minority groups, particularly Negroes and Spanish-speaking Americans, in the position of second-class citizens with respect to training and employment. Where employers and unions, together with community leaders, have acted forthrightly and consistently to insure equal opportunities for employment, the resultant change in employment policy has worked out well. Where the Federal Government has been vigorous in invoking its authority to require its officials and the employers working for it under contract not to discriminate against job applicants and employees because of race, creed, or national origin, traditional prejudices have been overcome.

"In spite of the advances toward greater equality of opportunity, Negroes are poorly represented in most skilled and technical occupations. They continue

to be barred for training and jobs that lead to skilled and technical work, especially in the South, but also in other regions. In many parts of the country they are still excluded from apprenticeship training programs. Despite the strong stand against discriminatory practices taken by many national and international unions, some local unions continue to bar Negroes from membership, and, as a result, from gaining access to skilled jobs.

"Overt discriminatory practices are not the only reason why the opportunities to acquire essential skills are not equal for all individuals. The basic education that a person receives, the information at his disposal when he plans his career, and the employment openings available to him all strongly affect his opportunities to become a skilled worker or technician. Consequently, communities that tolerate poor elementary and secondary schools and fail to provide adequate vocational guidance place major obstacles in the way of many of their citizens who seek to acquire skill.

"In order to provide more equal opportunities for all individuals to acquire skill, the National Manpower Council recommends that:

> "1. All employers hire and promote employees and all unions admit individuals to membership without regard to their race, creed, color, national origin, or sex.
>
> "2. Employers and unions and the joint apprenticeship councils, and committees eliminate the practice, wherever it exists, of barring individuals from admission to apprenticeship programs because of their race or national origin.
>
> "3. The President insure that the heads of Federal departments and agencies eliminate discrimination based on race, creed, color, national origin, or sex wherever it remains in Federal employment; and that the full authority of the Federal Government be used to prevent such discrimination in all work performed for it under contract."

(From the Council's statement, A Policy for Skilled Manpower, pp. 27–29.)

(See also, Student Deferment and National Manpower Policy, pp. 68–73, 78–80; A Policy for Scientific and Professional Manpower, ch. III; Proceedings of a Conference on the Utilization of Scientific and Professional Manpower, pp. 108, 131–132; A policy for Skilled Manpower, chs. VIII, IX, pp. 61–62, 71–73, 287–288.)

4. Improving utilization, both in civilian life and in the armed services

"During World War II, and again after the outbreak of hostilities in Korea, manpower shortages encouraged the search for new and more effective ways of utilizing available trained personnel. Under normal conditions, the weight of tradition and habit discourages changes in manpower practices and contributes to the ineffective use of personnel. Many steps have recently been taken to insure more effective utilization of our limited resources of scientific and professional personnel, but much remains to be done before this objective is fully realized.

"The Armed Forces are the largest single employer of manpower in the Nation. By improving their selection and assignment procedures, they have tried to prevent waste of the capacities of scientists and professionals as well as of technical and skilled personnel. There is need, however, for the Armed Forces to take additional steps to improve the effective utilization of their trained manpower.

"Policies governing the recall of reservists with scientific and professional training have not yet received adequate attention. Under present legislation, sole responsibility for the recall of reservists rests with the Armed Forces. Even though an extensive recall of reservists who are qualified scientists and professional persons would have the most far-reaching consequences for civilian work and life, there is no provision for civilian participation in the recall process. The National Manpower Council recommends that—

> "1. The President initiate a review of the existing legislation and administrative procedures governing the recall of reservists to active duty in order to develop a system that will provide for civilian participation in determining the distribution of scientific and professional personnel required to meet military and civilian needs.
>
> "2. Management intensify its efforts to determine the most effective balance among the different types of manpower it employs—scientific and professional, technical, skilled, and semiskilled—in order to insure efficient and economical operations and to provide for the further training of the manpower for which it is responsible.

"3. Business and Government intensify their efforts to develop executives who understand the importance of insuring that each highly trained person has the opportunity to utilize his capacities as fully as possible."

(From the Council's statement, A Policy for Scientific and Professional Manpower, pp. 27–28.)

"The national objective of insuring, through deferment, a continuing supply of well-trained men will be jeopardized if the Military Establishment wastes the skills and competence of highly trained men through poor assignments. Although the primary function of men in uniform must always be to contribute to the successful performance of the mission of the Armed Forces, the effective utilization by the Armed Forces of educated and trained men must be an important goal of national manpower policy.

"It is neither feasible nor necessary for the armed services to assign every man to a duty which permits him to use all his specialized training. The Armed Forces cannot assign every lawyer to duty as a judge advocate. The Armed Forces, however, should be expected to assign every man with full regard to his general training and competence. To assign a chemical engineer as a company clerk is wasteful; to assign him to an Arctic engineering project where his general training can be utilized may be desirable and reasonable.

"Some branches of the Armed Forces have recently taken constructive steps toward the more effective assignment and utilization of highly skilled and specialized personnel. The Signal Corps, for example, has developed a system for securing pertinent information from employers and trade unions about skilled workers, technicians, and scientists who are about to be called to active duty. The tagging of specialized personnel before they are inducted reduces the chance that they will be lost in the system, and provides a better opportunity to assign them with particular regard to their skills and competence.

"The Armed Forces can introduce several other changes, particularly in the selection and training of officers and noncommissioned officers, to contribute to the more effective use of highly trained men. In selecting and training noncommissioned officers for technical assignments, more weight could be given than at present to a man's civilian skill and experience. More could be done to insure that assignment of responsibility is made with regard to a man's skill and competence as well as his rank. Furthermore, the Armed Forces could select qualified men out of the enlisted ranks more rapidly for training and promotion to noncommissioned and commissioned officer status.

"A study of the sources from which the Armed Forces secure officers should lead to other improvements in the utilization of such personnel. The recently expanded Reserve officer training programs—which in fact constitute a second system of student deferment—should be reviewed to determine whether the Armed Forces plan to commission as line officers a disproportionate number of graduates of scientific and engineering colleges. If many of these men will have little opportunity to utilize their specialized skills during the 3 or 4 years that they are on active duty, an important national manpower resource will be wasted.

"The Nation's manpower resources are limited. If the manpower requirements of the Armed Forces can be reduced, the Nation will be better able to meet current civilian and military manpower demands, and at the same time make provision for securing long-run manpower objectives. Among the latter are a relatively short term of active service for inducted men and the avoidance of the extensive recall of reservists, as well as the deferment of students and apprentices.

"Several related steps would make it possible to reduce the military manpower requirements that must be met by Selective Service. By increasing the number of qualified men who enlist, and, much more important, those who reenlist and seek a career in the Armed Forces, the drain on the Selective Service manpower pool would be diminished. Increases in military pay, which Congress is now considering, bonuses for reenlistment, adequate housing, and an improved assignment system would add to the number of career men in the Armed Forces.

"Many duties in the Armed Forces can be performed only by military personnel. Others, however, can be efficiently and economically performed by civilians. With adequate ceilings on the employment of civilians, the Armed Forces should be able to substitute additional civilians for men in uniform in construction, procurement, warehousing, and clerical work.

"Total military manpower requirements could be further reduced if certain functions were to be performed on a contract basis. The essentials of the mili-

tary machine—the planes, the tanks, the guns, the uniforms—are all secured by contract. In recordkeeping, supply, transportation, and housekeeping, certain functions now carried by the armed services could similarly be performed by civilian organizations.

"Recommendations on military manpower policy:

"1. The National Manpower Council recommends to the Secretary of Defense that he establish a comprehensive program which will secure, consistent with the mission of the Armed Forces, the most effective utilization of highly trained and specialized men in military service.

"2. The Council recommends to the Secretaries of the Army, the Navy, and the Air Force that they review and modify the present methods of selecting and assigning highly trained personnel to noncommissioned and commissioned officer status with the aim of assuring that full weight is given to the civilian skill and experience of the man in the determination of his military assignment.

"3. The Council recommends to the Secretaries of the Army, the Navy, and the Air Force that they review the present procurement of officers to ascertain whether it results in utilizing a disproportionate number of the graduates of scientific and engineering schools as line officers.

"4. The Council recommends to the Secretary of Defense that he establish more realistic standards for induction and enlistment so that the Armed Forces can accept large numbers of men now being rejected because of minor educational, physical, or emotional handicaps, or because of a record of minor delinquency.

"5. The Council recommends to the Congress that it establish a pay scale and provide housing for military personnel which will encouarge reenlistments by men seeking to make a career of service in the Armed Forces.

"6. The Council recommends to the Congress that it set personnel ceilings which will encourage the Armed Forces to substitute civilian for military personnel wherever possible.

"7. The Council recommends to the Secretaries of the Army, the Navy, and the Air Force that they reduce the requirements for military personnel by increasing the number of functions performed for the Armed Forces through contract with civilian organizations."

(From the Council's statement, Student Deferment and National Manpower Policy, pp. 14–16, 18–20.)

(See also, Proceedings of a Conference on the Utilization of Scientific and Professional Manpower, pasim; Improving the Work Skills of the Nation, ch. 8.)

Mr. GINZBERG. This gives me a little bit more freedom to talk as an individual.

I have one other way of qualifying myself. I serve as consultant to the Secretary of Labor and to the Secretary of the Army on manpower and personnel problems.

I think that the only contribution that I can really make this morning is to try to raise some questions as to how to think about the problem that the committee is concerned with rather than to deal with specific recommendations as to how to solve it. I think that if I can make a small contribution by illuminating some of the more difficult issues it may be of some help to you.

I think I ought to ask the first question as to what kinds of manpower are short at the present time, for, as I understand it, the committee is preoccupied with scientists and engineers. But I think it would be a great error to concentrate solely on these groups.

We are particularly short, and have been for a long time, in the field of nurses. We have recognized more recently that perhaps some of our worst difficulties lie in the inadequate numbers of good teachers at the elementary school and high school level.

We probably are particularly short in such specialty fields, as for instance Arabic scholarship, which might contribute considerably to our intelligence work, so on and so forth.

So I believe we can misread the position which faces the United States at this time if we think only in terms of scientists and engineers. I think it is more likely to be correct to say that we are short of all kinds of good people across the board, all of whom may be strategic from the viewpoint of the present security and expanding welfare of the United States. It is presumptious, I believe, to simply concentrate on people called engineers and scientists and say they should be our only preoccupation. It can mislead us very badly.

The next point is that, as an economist, I am somewhat bothered by the fact that the usual way in which the market responds to a shortage in our kind of capitalistic society is to have the price go up for commodities that are in short supply. So that one way of thinking about how short we really are of engineers is to ask what has happened to engineering salaries, to use them as the key group for evaluation.

My colleague, Professor Stigler, at Columbia has just finished a major study on the earnings of engineers relative to other kinds of professional people for the National Science Foundation. He is very impressed with the fact that engineering salaries have hardly moved differentially as over against the salaries for other professionally trained people. That would lead one to suspect that much of the excitement one reads about in the newspapers about the so-called shortages of engineers is not backed up by the money purse of the private employer in this country. It is true that he is willing to hire more engineers at the going wage, but he does not seem to be preoccupied—at least as far as one can learn from the data, and Professor Stigler studied them very carefully—with paying extra amounts to attract larger numbers.

I raise the salary question only because I want to raise a related point. Many people are impressed with all of the advertisements appearing in the newspapers for more scientists and engineers. Well, the Government pays for that and, in fact, the people who advertise get an extra return in additional overhead. The more money they spend on advertising,the better it is for them.

Stigler did an analysis of the New York Times' advertisements for engineers and scientists and found that about, as I recall it, 98 percent were paid for by the Government.

This leads me again to put in some order of caution as to what it is that we are talking about when we say that engineers are so particularly short.

Then I want to raise the next point, and that is the danger of thinking about professional manpower primarily in terms of gross numbers.

I am impressed with the fact that American medicine stands at the forefront of all medicine in the world, and our big efforts over the last 30 years in medicine have not been to multiply the number of doctors but to improve the quality of the doctors we have been producing. We have really changed the average training of the average doctor from a 4-year medical course to an 8- or 10-year course. And our ratio of doctors to population has not gone up, but the quality of the available doctors has gone up very substantially. Maybe a good part of the answer of what seems to be a gross shortage of engineers is really a shortage of the quality of engineers that we have.

I would like to put that at least before you, Mr. Price, for consideration.

Another point is that in any new field—and this is particularly true of nuclear engineering and so on—it is inevitable that a shortage exists initially because no one could have been trained within the subspecialty until the subspecialty comes into existence. You cannot have nuclear engineers trained until nuclear engineering becomes a field.

That suggests something else. That is that the big strength of the country's professional manpower resources is how much depth and flexibility is imbedded into the trained group so that they are able to meet new challenges.

So much for the concept of a manpower shortage.

Now I want to come to a few comments about the widely expressed fears that the Russians are outproducing us with respect to these categories of trained people.

The first point that I want to make is that there is not much sense in considering annual output rates unless one relates that to the basic supply. That is like an inventory problem. If we have 600,000 engineers, and we are producing twenty-odd-thousand a year, the annual output in this country is only 3 percent of the total stock. That means that many of the comparisons look to me to be very strained when they concentrate primarily on output, to the neglect of the stock.

More importantly, I do not think it is possible to make any sensible comparisons between one type of manpower in one country and the same type of manpower in another country unless one relates manpower resources to other factors which have to be present to insure efficient output. That means raw material, capital, skilled manpower, management, and so on.

I do not pretend to be an expert on Russian manpower, but I think I know enough about the situation to say that we have a larger number of skilled workers in this country who work together with engineers than do the Russians. This means that engineers on the whole work at a higher level of competence in the United States than I believe they do in Russia.

For a true comparison one would have to think about not engineers alone, but engineers in relationship to the skilled people who support them.

Another point. A very large part of our business managers in this country are not engineering graduates, although many companies now like to have engineers in general management. I suspect, from what I have been able to learn from those experts who know the Russian situation, that they tend to use engineers much more heavily in general management.

Representative PRICE. Of course, we are getting closer to that, too.

Mr. GINZBERG. We are closer to it. It is prejudice we have. When five men—all engineers—become president and vice presidents of a large company.

Representative PRICE. Not only in the management field but also in the salesmanship field.

Mr. GINZBERG. Yes. On the other hand, I would recommend to your consideration Mr. Shepard's article, who I believe graduated in engineering from Massachusetts Institute of Technology, and who is a member of the board of directors of Standard Oil of New Jersey. It appeared in the Atlantic Monthly some months ago. In it he offered some pretty persuasive arguments about the dangers of management reproducing itself along the engineering line too heavily.

Another point I would like to make along this same line is that from our human resources studies at Columbia, there appears to be a great style factor in these things. If one company begins to gobble up a lot of engineers because it thinks that they are going to be in short supply, other companies, just as a competitive response, will decide that they too had better get some more of these fellows.

I remember a discussion I had with the Chief of Staff of the United States Army some years ago, in which I recommended to him not to place additional Officer Reserve Training Corps programs in engineering and technical schools because, I said, when he gets ready to use the graduates for the line-officer jobs they will be in pretty short supply and industry will want them, and he will find himself in trouble.

He said, "If these people are good for industry, why are not they good for the Army?"

So there is a fashion involved in these matters also.

The next point I want to make is the danger involved in crude comparison. This is illustrated by Mr. Sulzberger's article as recently as yesterday in the New York Times, in which he says the Russians have 50 million farmers to raise their food supply and we use 7 million. Obviously, the fact they have more manpower doing a particular job in their country, seven times as much as we, does not mean they are stronger by virtue of that fact. Gross comparisons of manpower without relevance to output and other factors just does not give one a meaningful answer.

I would like to push that one point further.

The logic, as I see it, that many people are following, runs like this.

Scientists and engineers are needed in larger number in order to strengthen the military equipment and peaceful development of the whole nuclear field, but primarily the military front, for only thereby will we be able to strengthen our defense position.

Now, undoubtedly a strong military arm is a part of a defense position in the modern world, but it is not by any means the whole story. I think it is very important to raise some questions as to whether we might not gain differentially more strength from a hundred additional experts on the Far East or on the Middle East, from people who have particular skills, let us say, in psychological and mass communications, rather than getting another 100 or 200 engineers when we remember that our stockpile numbers 600,000.

This is a warning against the crudity of equating numbers of engineers with better military equipment with a maximum defense position. I just cannot see it that way. It is much too simple.

I would like to go on and set out the environment that is determining our present situation.

We are in a boom in this country. The President, as recently as yesterday, in his press conference emphasized that, in his opinion, there was not much more that could be done to speed the missiles program because we were using all of the available scientists that had skills in this area; we were using all of the available facilities, and we were using as much money as could be intelligently employed to push the program ahead as quickly as possible.

In this connection, it is important to emphasize that additional money may slow progress rather than accelerate progress, because money can pull resources in directions away from where you want them as well as toward particular objectives.

Last week I had a chance to talk to the president of one of the largest manufacturing corporations in the United States, and I asked him how he determined the size of his defense work for the United States Government. He said he limited it to about 20 percent. He said he tries to take on those contracts which fit his company's skills and competencies best. And I would add probably those things which he thinks eventually will be useful to advancing his civilian production.

I said, "Does not the Government periodically push you to do more?"

He said: "Yes, it does; but that is about all we feel like doing or think we can do in terms of our total program."

With the United States in a boom, I submit, Mr. Chairman, that the only way that we could really significantly increase our defense efforts in the immediate future would be to cut something else back in civilian production.

Mr. Sulzberger writing in the New York Times the other day emphasized that the Russians did not even have any pepper on their table, not to mention adequate housing in their cities. That means a controlled communistic society like the Russian can increase its defense efforts if it is willing to make the population pay the price in terms of consumer goods.

I think we have reached the point where we just have to face up to the present state of extension of the economy—if we want more cannon, we will have to take less butter. This is a decision of value facing our democracy.

The next point relates to the widespread impression that the armed services are a big waster of scientists and engineers.

I have been working with the armed services uninterruptedly since early in 1942. I like to believe that I know their shortcomings as well as anybody because I have had a chance to see them at close quarters. But I think that is a very dangerous doctrine to say the armed services are wasting scientific and engineering manpower because they always fail to give a man an assignment exactly commensurate with his training.

As I see it, the armed services have a substantial need for a larger number of able people with scientific and engineering training in order to provide strong management for a billion and a half dollar program a year.

I would submit in support of my judgment Dr. Mervin Kelly's—the president of Bell Laboratories—subcommittee report to the Hoover Commission, which estimated that a 25-percent improvement in efficiency in the research and development program of the armed services is possible over time through better management. The only way they are going to get better management is to get some people with good scientific background, get them exposed to the military, interest them in a career in the military, and help the military build up stronger management.

I think we go on in a circle trying to increase scientists and engineers unless we also improve the quality of management at key points. I think the notion that the armed services are not entitled to a reasonable supply of scientists and engineers, is a most self-defeating approach. I think it is particularly reprehensible to take this point

of view at a time when the predominance of our total national effort is devoted to nondefense activities, and I do not see the logic of keeping engineers out of the armed services so that they can take employment in candy and perfume factories.

Representative PRICE. Several members of the committee are vitally interested in that particular subject you are discussing. We concede today there is a great improvement in the manner in which the military handles this type of manpower, but before some of these hearings started up here there was a great amount of waste and mishandling of that type of manpower.

Mr. GINSBERG. I would agree. From what I have seen there has been sizable improvement over time, but I think we should be very careful now in current evaluations of what the armed services do that we do not carry over an old position where they failed to make as effective use of these specialists as they should in the current situation.

Representative PRICE. I think that is true. But from what happened in the past it is a pretty good indication you have to be on guard in the future.

Mr. GINSBERG. I would agree to that, sir.

I want to come now to one of the points which I gather is of particular interest to the committee, and that is—What could a large scholarship program do, particularly at the point of transition between high school and college in accelerating the number of good young people who would go on for higher education?

I start with a very strong prejudice in favor of the full development of all of our human resources. Therefore, I would like to believe that a large scholarship program would give us substantial relief.

I must point out, however, that, as a research scientist in the manpower field, there are some very serious limitations about the probable yield from such an effort.

The difficulties that I see are these:

A very high percentage of able youngsters fail to get properly prepared for college. What is more, they are so uninterested in their high school that they fail to study properly. So although they have native talent and under proper stimulation would have made good college material, they really are not at the time of their high school graduation.

The second point that strikes me is that a very large part of our total supply of able people in the country are women. The National Manpower Council is just completing a 2-year study on woman power.

For many reasons women—women are not as desirous as men of going on to college or to become, let us say, serious students in the more difficult fields of mathematics and science.

The outstanding reason is that at the present time 50 percent of all women in the United States marry before the age of 21, and in the west coast cities 50 percent marry before the age of 20. Very few finish college by that time. So you have deeply built-in value problems and on age of marriage, age of women when they begin to have children which affect the development of women's potential.

Another point is that I am convinced that the numbers of people who can be interested in the field of science is limited and we have had large percentage increases in the last few years. People have been

attracted to engineering. I am by no means certain we have not done an overselling job.

After the war, one of my students at Columbia did a followup study of the Army specialized training program where special pressures were exerted to push soldiers into engineering.

The student studied 20 excellent graduate engineers. All were B-plus or A-minus students from top schools, and they all left engineering to go into business and other fields of specialization.

In my opinion, in our kind of a society, with large numbers of opportunities available to people with different capacities and interests, we have rather narrow bands within which people can be moved around. This is a further warning about how much can be accomplished by even a very lucrative scholarship program.

A further point, in this connection is to raise for your consideration, the heavy attrition that takes place even today in engineering schools. That is, a very high percentage of those who enter do not complete their course of study. This is independent of the also large numbers who complete their study and immediately or later never use these engineering skills.

Surely in the short run, these are quite severe limitations as to the proportions that can be shifted between fields—profitably. I am not at all certain that when one tries to use major pressures to alter proportions the result is good.

Dr. Pegram, the former dean at Columbia, who had a lot to do with getting the atomic bomb work started, told me that in the late 1930's he was unable to place in American industry a physicist; he usually had to classify him as a chemist in order to get him a job because American industry, as late as 1936–38, with few exceptions, was not hiring physicists.

Then you enter into a tremendous development of nuclear physics and, of course, now industry will grab any physicist that they can lay their hands on.

This morning's New York Times has some very important reports about a breakthrough in biology. As of this moment in time biologists are surplus relative to engineers and physicists. I do not know whether in 5 years the acute shortage may not be on the biological side while we will have been pulling in the intervening period to increase the number of engineers.

It takes a tremendous amount of responsibility, which I would question whether the Government or any other group really would want to take upon itself, to foretell the future as among specific fields of human knowledge.

I think what one can say is that as much information as possible should be put before youngsters. They need guidance but not direction. The more solid their training, the deeper their training, the more control they secure over mathematics, the further they go in their general training, the more likely they will be to have the flexibility within themselves to meet changes that will occur as research changes the face of science.

But I am very worried about reading future demands from present market situations. The outstanding case of error occurred in engineering itself, where, in 1950, the United States Department of Labor, together with the engineering societies, made a very serious miscalculation.

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Or, if you prefer the physics example that I offered you about the late thirties, guessing is very risky.

I have one other example.

In the 1930's an acquaintance of mine decided to study Chinese at Harvard. People thought him queer—Theodore White, the author, later served for many years as senior correspondent in the Far East. His esoteric decision to study Chinese at Harvard paid off very big for the United States when we became more heavily involved in the Far East, which was something most people did not conceive possible in the 1930's.

Now, in conclusion: All I have tried to do, Mr. Chairman, this morning is to put some ideas on the table which will help you and the members of your committee to think about the problem more deeply.

Representative PRICE. We certainly appreciate that, Doctor, and you certainly have thrown out a lot of thought-provoking ideas.

Mr. GINZBERG. I am really operating as a teacher in the manpower field rather than a prophet in the manpower field.

In conclusion, I would say these are the things that strike me as of this moment at this time:

We are at the top of a boom, and if the United States is seriously worried about its defense position, it has to be willing to give somewhere along the line in the utilization of its resources and transfer some from low-priority projects to high-priority projects, by cutting back in some regards.

Even then I am not sure, for as the President pointed out in his press conference yesterday, we may not be able to speed high priority projects very much faster than at present. But I do believe, if the country is convinced that it has to step up its military defense program and speed development, something else will have to give way.

The second point is that no increases in supply which are instigated now can possibly have significant yields until 6 to 10 years from now, because it is not the 4-year engineering graduate who is sought after but the man who has acquired 4 or 5 years of experience.

So that if we are to begin to increase the supply of able people—and I am in favor of doing this across the board—we much recognize that the relief will be 6, 7, 8, 9, or 10 years in coming.

That brings me to the third point. That is that we should pay much more attention than we have paid to problems of utilization, because, if we have 600,000 engineers and we can, over the next 3 years, make a 5 percent improvement per year in the effectiveness with which these people are utilized, that is the equivalent of more than 3 years' output.

I think that both in the armed services and in industry—and I think industry should not be let off too easily—there is substantial underutilization of our able people. This is true at universities, too.

That means the country can do much more than it has yet done to help itself by a more effective approach to utilization.

I had the opportunity to help the Secretary of Labor work out his skilled manpower program a year ago. One of the things we recognized was the substantial relief that could come by shifting emphasis from increasing the number of scientists and professionally trained people to increasing the number of skilled and technical people, whose

training period is much shorter and who, by working together with the engineers and the scientists, could expand the scope of the scientists themselves, because the production process is always a question of teams of people working together.

I think for the country as a whole we have not done nearly enough to improve the quality of our related manpower resources below the professional level.

There is a document which the Department of Labor has just published called The Skilled Work Force of the United States or some similar title, which I will submit to you, sir, on behalf of the Secretary of Labor since I helped to prepare it, which indicates what this problem is. It was presented to the Cabinet earlier this year.

Representative PRICE. Is that "Improving the Work Skills of the Nation"?

Mr. GINSBERG. No, that is the National Manpower Council's book. What I referred to derives from the work of the National Manpower Council in part, but it is a special little booklet put out by the Department of Labor. The Secretary of Labor has been aggressively propagandizing all over the United States the importance of paying attention not only to increasing the number of engineers and scientists but raising the quality of the skilled work force and technicians. These are the people who work with the scientists and engineers.

(The document referred to is on file with the Joint Committee on Atomic Energy.)

Mr. GINSBERG. The next point I want to impress upon you is that I have always taken the Russians seriously in all regards, including their stress on education—for this goes back to Czarist times. The interest of Russia in catching up with the West predates the Communists. They have been concerned with their lagging behind for a long time. The Communists have simply given it a new push forward.

Although we must take the Russians seriously, they are not quite as foolproof and as wise as they sometimes seem to be.

Within the last week the New York Times reported that last year one-third of all the managers of the collective farms had to be relieved from their posts because of corruption.

Now, if you have a controlled society which depends for its expansion on the output of agriculture—and this is fortunately one of the Russian bottlenecks—and one-third of all farm managers are corrupt, we can see the Russian picture a little bit more broadly.

There is another point about Russia which we have just uncovered at Columbia that may be of interest to you.

We analyzed how it happens that their annual production rate for engineers and scientists seems to be, relatively speaking, so high in comparison with our own. The key point has to do with the way they use their womanpower: First, almost their entire medical service is handled by women, they have very few male doctors, which means that many men who would normally go into medicine in this country go into engineering and science in Russia because women are carrying the medical service; and, second, as I say, the number of women going directly into engineering in Russia has no counterpart at all in the United States.

When you make allowance for this one factor of womanpower you have explained almost all of the gross differences in current and prospective production rates.

That leaves us with some very serious questions. Do we want to turn our kind of society around and put pressure back of women, who represent half of the potential brainpower of the United States, to take much more seriously scientific careers—even if they leave employment for the period of marriage and the care of young children.

This is a subject, again, that the National Manpower Council is dealing with in detail in its forthcoming book.

As far as the scholarship program is concerned from what I heard of Mr. Coombs' testimony, I would say that I surely like to use money to facilitate any good purpose, and I think that the Federal Government, if it could give some additional impetus to enable poor but able students to go on to college, even though the numbers will, in my opinion, be much more restricted than you hope—nevertheless I am surely friendly to the idea, with one proviso, and that is it would be a great disservice to the United States if these were categorical scholarships, limited to people making particular occupational selections.

I believe we should reinforce our basic idea of freedom in our society, by putting information before the individual. But one of the hallmarks of our kind of a society is for the individual to pick his life's work. I think it would be a great error and would be a disservice to the country if we tried to push people around and direct them into current shortage fields.

Finally, I think that the one thing that one does not want to do is to establish a Maginot Line kind of thinking, in which the future security of the United States is seen primarily or solely in terms of the numbers of scientists and engineers. I think that is the kind of a Maginot Line that can get us into just as bad trouble, if not worse trouble, than building cement walls.

I believe it would be much better to improve the high schools of this country and improve the quality of our teachers than it would be to increase the number of graduate engineers in the short run. That is, since we have to pick targets, I am surely not in favor of picking the target of increasing the supply of engineers from 600,000 to 700,000 as a first priority target.

Likewise, I am not at all sure that many of our most strategic manpower problems are not in terms of tens or hundreds rather than in terms of thousands and tens of thousands. I could very well conceive that a very selective kind of a program and proper employment opportunities for X number of people who really become experts on the problems of the population, geography, economics of Africa and Asia could pay off out of all proportion in terms of defense and security of the United States far beyond adding another 10,000 or 20,000 engineers.

So I would hope that the real contribution of this committee would be to alert the country to the importance of developing its latent brainpower across the board and to reinforce the basic democratic principles that people should be encouraged to follow their inclinations and their capacities in light of their knowledge of the urgencies and opportunities that exist; and that in this fashion one will move

further toward the objectives of the committee than by adopting any narrow approach aimed at multiplying the number of engineers and scientists.

Representative PRICE. Thank you very much, Dr. Ginzberg. We appreciate your cooperation and the time you have given to us this morning. You have, as I said, thrown out many thought-provoking ideas the committee will certainly have to take into consideration.

Mr. GINZBERG. I am very glad to have had the opportunity.

Representative PRICE. The next witness is Mr. Philip Powers, Internuclear Co. Mr. Powers, would you mind locating your company? I see you are a neighbor of mine. I am from East St. Louis, and, of course, you know St. Louis is a suburb of our city.

STATEMENT OF PHILIP N. POWERS, PRESIDENT, INTERNUCLEAR CO., CLAYTON, MO.

Mr. POWERS. Yes, I am quite aware of it. We are just a little on the other side of St. Louis in Clayton. The purpose of our company is to provide consulting, design, and engineering services in the nuclear reactor field.

Mr. Chairman, my name is Philip N. Powers, and I wish to thank you for your invitation to appear before you today. I am president of the Internuclear Co.

I have some recommendations for your consideration on how to deal with this tough problem of how to increase the supply of scientists and engineers, but before discussing this question, you may wish to know something of my own qualifications.

During the past 20 years or so, I have been a teacher both at the high-school and college level, I was a civil servant for nearly a decade, and for the last 5 years I have been in industry. I have a doctor's degree in nuclear physics, and I have been directly connected with atomic energy matters during most of the last 10 years.

It was during the war, when employed by the Navy, that I first became concerned about the shortage of scientists and engineers and about the necessity for making the best possible utilization of the supply which we have. As a result, it became part of my job to find ways for increasing the professional skill and competence of scientists employed in the Navy, not only to gain better utilization of their talents but also to help increase the attractiveness of civil service to the high-grade personnel which were required.

Then shortly after the war, I was employed by the President's Scientific Research Board to help prepare a report on the scientific manpower situation. As a result, I had primary responsibility for the preparation of volume 4 of the so-called Steelman report entitled "Manpower for Research."

For several years I was employed by the Atomic Energy Commission as Adviser on Scientific Personnel. It was my job to help attract back to the atomic energy program of this country many of the high-grade scientists and engineers who had moved away from it at the close of the war.

In 1951 Senator Symington, who was then chairman of the National Security Resources Board, and concerned just as he is today about this scientific manpower problem, appointed a special committee to advise him in this field, particularly in regard to utilization. This

was known as the Scientific Manpower Advisory Committee and was under the chairmanship of Dr. Charles Allen Thomas, president of the Monsanto Chemical Co. My job at that time was to serve as executive secretary of this committee.

Until recently I served as the director of the atomic project for Monsanto. As you may recall, Monsanto was one of the first to establish a study team for the investigation of the feasibility of privately financed power reactors. Leading the study team was my job.

At present I have certain other responsibilities which are pertinent. For example, I am chairman of the committee on atomic energy education of the American Society for Engineering Education. This organization is composed primarily of engineering college faculties from throughout the country, and the major purpose of this committee is to help the engineering colleges get on with their job of making sure that their graduates have the competence and the training required for work in the atomic energy field.

In addition, I am chairman of the atomic energy panel of the Engineers Joint Council. Testimony from this organization was, I believe, presented to you yesterday by Mr. William Cavanaugh.

I serve as a member of the Committee on Specialized Personnel, which advises the Office of Defense Mobilization on matters relating to the supply and utilization of scientists and engineers. Also, I serve as Chairman of the Advisory Panel on Scientific Manpower Information of the National Science Foundation. Finally, as a member of the United States Chamber of Commerce's committee on national defense, I chair the subcommittee on manpower.

So much for my qualifications to testify, and if I may, I will now proceed with the question which is before you.

To begin with, I believe that this question is terribly important, and may I say that I think that you are performing a very great public service by taking the time to study this problem and to bring it before the American people.

It seems clear, first of all, that the strength of this country depends in very large measure upon the continuing advancement of our technology. This is true whether we are thinking of national security in a military sense or in connection with our world leadership in increasing the standard of living and in finding the constructive and peaceful applications of atomic energy and other segments of science and technology.

It is also clear that our leading position in technology is being seriously challenged by Soviet Russia. We know that they have made substantial progress in atomic energy and in other fields, and it now develops that they claim to be close to having missiles capable of carrying H-bombs. It is I think abundantly clear that we cannot afford to be complacent. It has been going on for many years. We are just now at the point where, over on the other side of the Iron Curtain, they may be getting close to catching up with us, and we must think seriously about what is going to happen in the future—say during the next 10 years.

Putting it differently, I do not believe that this shortage of scientists and engineers that we are concerned about in 1956 is a transitory thing. The spectacular advances which we have seen so far are just the beginning, and we cannot afford to stand by and let Russia and its satellites learn more about these things than we do.

Now as you know, there is occasional talk about surpluses of scientists and engineers. I remember very well back just prior to the big engineering and science classes of 1950 that there was much wringing of hands about where all of these young people were going to find jobs. But I remember too a survey which the American Society for Engineering Education completed at the end of that school year just prior to Korea showing that practically all of the individuals had found jobs. Then came Korea and, in subsequent years, fewer graduates along with expanding requirements.

To measure the magnitude of the shortage on a statistical basis at any given time is a very difficult thing to do. Statistics are famous for being difficult to interpret, and as soon as you start counting unfilled jobs which can't be filled anyway because the people aren't available, it's hard to know just what you are getting. It is possible to put together numbers which indicate that if we had more scientists and engineers, there would be jobs for them. But we know this ahead of time. All we have to do is to talk to the man who is trying to hire them. The newspapers are full of ads for scientists and engineers, and we all know how difficult it is to get well-trained teachers of high-school science because of better-paying jobs elsewhere. The point is that we need all we can get, and there is every indication that for the foreseeable future, manpower will be the chief limiting factor in determining our progress into the guided missible field, or into atomic power, or into finding a cure for cancer, or what have you.

We all know that we must emphasize quality as well as quantity. Large numbers of incompetent people will not meet our requirements, and on the other hand, a small number of very able people will not find enough hours in the day to do all the things we wish to do.

This means that we must, if we can, encourage more young people to go into scientific and engineering fields, and at the same time we want the graduates who go out into important jobs to be of as high quality as possible.

There are a variety of things which we as a Nation can do to help this come about, and I know that you have had many excellent suggestions along this line from the witnesses who have appeared before me during these hearings. Instead, therefore, of going into detail, I will, if I may, simply emphasize the points which seem particularly important to me, and then I will proceed to a specific proposal for your consideration.

The main points which occur to me are, first, that we should make sure that competent young people who wish to do so are not prevented from becoming scientists and engineers because they cannot afford to go to college. In other words, we should make sure that scholarships and fellowships are available in sufficient quantity so that our national leadership is not threatened by the lack of a few dollars to train good people.

Next, we should make sure that the salary structures at primary, secondary, and college levels are sufficient to attract capable teachers. Also in this connection we should make sure that our teachers receive the recognition and the prestige which is commensurate with their high responsibility of training our young people.

Also, we should make sure that our schools have the equipment and facilities which they need. This is primarily a matter of efficiency so

that the time of both the teachers and the students can be used to the best advantage.

Also, we need programs to help the teachers keep up to date, to learn more about their fields, and to have the benefit of knowing about successful experiences of others. In this connection I am impressed with the program of summer institutes which the National Science Foundation has been supporting and which Dr. Harry Kelly told you about last week.

Finally, we should do all that we can to insure the best possible utilization of our scientists and engineers and to see that they have opportunities for continued professional growth after they have accepted jobs. This applies whether the individuals are employed by a college or university, by industry, or by Government, including, of course, military service.

While making these general observations, there are two cautions which I would like to suggest. First, I am confident that these things can be done successfully only if they take root at the local level. To be sure, leadership and a certain amount of financial support on the part of the Federal Government is essential, but in the final analysis it will be the people in their own communities throughout the Nation who will determine the success of our schools in training the scientists and engineers that we need.

My second caution is that we must not forget about the other fields. It is entirely possible that the large numbers of science and engineering graduates that we hear about in Russia are in part the result of pressure by the Government to get into these particular fields at the expense of some others. So far as we are concerned, I do not know who would be wise enough to say that it is more important for competent students to go into science and engineering, or into the humanities, or social studies, or into the arts. Our best answer is, therefore, the answer of freedom itself. We leave it up to the individuals concerned to make these selections, but we try to give them the information they need to make intelligent decisions in the light of future requirements and considering their own interests and aptitudes.

Now I would like to come to my main point. I believe that all of the things that we have been discussing need to be done, but that this will still not be enough. All of these things will help. They are very important, but in the final analysis there are only so many people in this country, and we have a great many other things to do outside of scientific laboratories.

What is needed is a new approach to the problem. We need a program which holds promise, over a period of years, of increasing by an order of magnitude our manpower base for the advancement of technology. We need to make sure that we are not surpassed, either in quantity or in quality, by the block of nations behind the Iron Curtain. Populationwise we are seriously outnumbered, and so, basically, my proposal is to view this whole problem not just within the confines of the United States in this year of 1956, but instead within the confines of work of the entire free world over the next decade, or even over the balance of the 20th century. If we examine this manpower problem as a member of a community of free nations, with the ability to cooperate with one another in marshaling our total scientific resources, then we should have no fear of not being able to stay ahead.

Specifically, this would mean working with those other countries to develop programs along the same lines as those which we have been discussing for the United States alone. It would mean extending these programs to apply to young men and women in other countries as well as in the United States. It would cost a substantial sum of money, but still very small in comparison to the present cost of national defense.

In concert with these other free world nations, we would set up scholarship and fellowship programs; we would help to make sure that the schools have the equipment and the libraries that they need; we would help to make sure that the salary structures are sufficient to get good teachers; and we would organize on an international basis such programs as the summer institutes which the Science Foundation is supporting here. To the extent necessary, we would make some of our people available to help them, and in return we would invite their assistance to an increasing extent as time goes on.

The first job would be to make a thorough analysis of the situation, and I believe in this connection that your recent report, Mr. Chairman, entitled "Engineering and Scientific Manpower in the United States, Western Europe, and Soviet Russia" is an excellent beginning. As this report demonstrates, we are not alone in feeling the pinch of the shortage of technically trained people. The pinch is getting more severe in the so-called underdeveloped nations as well as in the more powerful countries of Western Europe. We would, therefore, be providing very real assistance to them as well as strengthening our own national security, and I would expect the various activities to be financed on a joint basis.

This first job would include working with these other countries to develop estimates of their potentials for the production of competent scientists and engineers during, say, the next decade. Also, we would need to measure these potentials against their probable requirements for their own industrial expansion. The study should include not only Western Europe, but also the countries of South America and the Far East. Then out of this study could come plans for specific activities along the lines which I have outlined.

To start this ball rolling, there is not to my knowledge any single agency which would be suitable. I note that the President has recently appointed a National Committee for the Development of Scientists and Engineers, and I hope that they will interpret their charter broadly enough to approach the problem on this international basis. But in the meantime I would like to suggest the possibility of NATO taking the initiative. I know that this applies only to Western Europe, but this would still be an important start. I am no expert on the functions of NATO, but I was much impressed with the statement of our Secretary of State earlier this week before the Associated Press when he suggested that NATO take on some new responsibilities and, in particular, when he said, "We must increase the unity and dynamism of the free world by greater emphasis on cooperation for something rather than merely against something." To work together for a stronger base in science and engineering would certainly be for something. It would be in keeping with the spirit of this excellent suggestion, and it would be a big enough job to command the attention of an international organization of that kind—in fact, it might well lead

toward closer relationships between NATO and other free world countries. Perhaps other international organizations could be brought into it. Perhaps the Organization for European Economic Cooperation would be more appropriate than NATO. In Latin America, the Pan American Union might help out, and in the Far East there is SEATO. To determine which of these organizations would be appropriate for this purpose would obviously require careful study, and it may be that we need a new organization altogether.

The important thing is to get started somehow. This would be one of the best investments we could make—not only for our long-range national security, but also for strengthening our world leadership in helping to improve the standard of living and the well-being of people everywhere.

Representative PRICE. Mr. Powers, you evidently feel that there could be political and economic advantages accruing to the United States and to the free world with an abundant supply of scientific and engineering and technical manpower.

Mr. POWERS. I certainly do.

Representative PRICE. Could you foresee the Russians using such a supply in the same manner?

Mr. POWERS. Absolutely. I see every indication that this is going on right now.

Representative PRICE. We deeply appreciate your statement, Mr. Powers, and thank you for your cooperation with the committee. Thank you very much.

Mr. POWERS. I appreciate the opportunity to be here, Mr. Chairman.

Representative PRICE. The next witness will be Dr. F. Wheeler Loomis, American Institute of Physics. Dr. Loomis.

STATEMENT OF F. WHEELER LOOMIS, AMERICAN INSTITUTE OF PHYSICS

Mr. LOOMIS. Thank you very much, Mr. Chairman, for inviting me to attend this meeting.

Shall I identify myself first?

Representative PRICE. Yes.

Mr. LOOMIS. I am professor of physics and head of the department at the University of Illinois, and also director of the Control Systems Laboratory there, which is a military laboratory.

I was during the war associate director of the Radiation Laboratory of the Massachusetts Institute of Technology,, which developed the microwave radar and which was a laboratory of about 4,000 people.

I also was the initial director of the Lincoln Laboratory, also at the Massachusetts Institute of Technology, which is concerned with air defense of the continental United States. I am now, as I said, director of the Control Systems Laboratory at the University of Illinois, which has to do very largely with military problems.

I am also a member of the Scientific Manpower Council and on the divisional committee of the National Science Foundation for Manpower and Education.

Incidentally, sir, I am speaking only from rough notes. I have not a prepared statement, and I should be delighted to be interrupted at any time.

Representative PRICE. Thank you.

Mr. LOOMIS. Before I came here I thought it would be unnecessary to argue at all that there existed a serious shortage of scientific and engineering manpower, but after hearing Dr. Ginsberg's statement this morning perhaps I should devote a little attention to this because I differ with his conclusions.

I have no statistics, but have had to hire scientists and engineers for the department of physics over many years, then to staff the Radiation Laboratory at Massachusetts Institute of Technology, where we must have had 1,200 scientists and engineers by the end of the war, at which time for one reason or another it was fairly easy to find them. You had only to locate the good ones and invite them to come and they came—then later in 1951 had to establish the Lincoln Laboratory, where by the time I left we must have had about 800 scientists and engineers, where it was much more difficult, and one got a large group together but not of the quality needed in the Radiation Laboratory, and finally in the present day for the Control Systems Laboratory. It is now, in my experience almost impossible to hire them.

So just from experience, without any statistics, I have come to the conclusion that the situation has completely reversed itself. There is now a desperate shortage of scientific and engineering manpower and one which is affecting the military and atomic energy progress in a very radical way.

I have seen the report, I think, which Dr. Ginsberg referred to, which was made to the National Science Foundation and have looked casually at these statistics.

I just do not believe any statistics which contradict my obvious experience.

Looking at them a little bit critically, I would make these qualitative suggestions:

What is wrong with them in particular is one thing Dr. Ginsberg mentioned—that there is essentially no measure of quality, there cannot be any measure of quality, and in dealing merely with numbers you do not deal with the actual situation. The shortage is not a numerical one but a shortage of qualified scientists.

Another systematic error in those statistics is that they primarily deal with salaries of engineers by lumping the newly hired ones in with the ones that have been employed a long time. It is a well-known fact that salaries of people who have been in a company for a long while and are older people do not go up so rapidly as those they have to hire from the market.

A survey concentrating on those newly hired would be more impressive statistics, but I do not believe any statistics could convince me in the face of my rather extensive experience in trying to get scientists and engineers.

I cannot see how it can fail to be true that we are faced with a desperate shortage. I would have thought that your committee would long since have had a great deal of evidence to this.

I pass on from that point to mention a different one which has been very much in my mind. This is the great underuse of enlisted scientific personnel.

I do not wish these remarks extended to the scientific officer personnel. I know many highly educated scientific officers who are doing splendid work. They are usually not serving as scientists as such but as people who understand science, who have an appreciation and know

what is good and what is bad, are able to judge it, to tell what is the most promising line of development, and so on.

So I agree with Dr. Ginsberg that there is a need for many more good scientific officers in the services. My point, however, is that, and I have had some experience, I think you could almost generalize and say that hardly any enlisted man who is a scientist is being anywhere near fully used.

I know of two military laboratories—I would rather not mention their names, but two of the best and most scientific of laboratories. Both happen to be in the Army—where of recent years through the draft they have acquired rather large numbers of highly trained enlisted men. There is a high proportion of Ph. D.'s in physics and in other related subjects in these laboratories. These men, of course, are enlisted. There is not much even of an opportunity to promote them to be corporals and sergeants.

These men are subject to military discipline and military use on routine duties, such as kitchen police, policing the grounds, a whole variety of such things. They are interrupted daily by the sergeants, who take them away from their scientific duties to do the routine duties.

They often put in considerably more than a 40-hour schedule—the figures in one instance that we got were that they put in about 35 hours a week on routine duties and 35 hours a week on scientific duties. This makes them so much fatigued they are not much good as scientists, makes so much interruption that they cannot be given responsibility. In general, they are not entirely ineffective, but much less effective than they would be if they were in ordinary civilian employment or were in a Government laboratory or AEC laboratory or something of that sort.

I know that this situation has been somewhat corrected in recent years by the diminution in the draft calls and by certain corrections that have been made in the use of scientists. But I think you can say, with very few exceptions, the Army has no real use for enlisted scientists. They often claim that they have. When you find a case where the Army or Air Force maintains that it is indeed using the scientist as a scientist you will usually find he is underused, he is used as a technician. A man with a Ph. D. in physics serving as a radio technician is only being a few percent used, in my opinion.

This is one place where fairly immediate improvement can be made.

I am sympathetic to these long-term devices for improvements, such as improving high-school teachers, but it is going to take many years—by the time you train a high-school teacher, and then he trains a student, and the student goes through college and graduate school and starts working and developing something, and the thing developed, is manufactured and put into use, the time interval between the beginning of that process and the end effect is 20 years or so.

I am saying there is an immediate thing on a small scale which could conceivably be done now, and this is the use of any enlisted scientists in a much more efficient way.

What could be done—it seems difficult but it is possible because it is already occasionally done—is to detail such men to civilian nonprofit organizations working on military or AEC problems. They can be

and have been so detailed, and I have two such enlisted men working for me now.

I think of one doctor of philosophy who is really top quality, one of the ablest young men of his generation, and who was drafted and was sent to our organization. He is a private, but he is in civilian clothes, and he operates exactly as he did before he was drafted, and with very fine results.

I think the point of keeping him in civilian clothes is quite essential. It means he is under no control of the sergeants.

This device could be exploited much more widely. It is rather rare at present. The question is, "How can one go about it?"

The Army, I feel, can only with difficulty use such men well because the ingrained attitude of the Army is that one private is about as good as another and for sound disciplinarian reasons should have the same amount of kitchen police and the same amount of everything else.

There is also a similar feeling that governs selective service.

On the other side is that if we want to win the war we have to recognize that people are very different, and that trained scientific personnel are very scarce, and something should be done about it.

The Army has the power now, and a little pressure from Congress might persuade them to use it more than they now do.

Another scheme that has been suggested that might effect this same benefit is the so-called scientific personnel board, a board of people which would have power both over selective service and over the use of scientists in the service, which would have power to go into the Army and find out how enlisted scientists are being used, when they are being misused or underused, and recommend different assignments for them.

This proposal of a scientific personnel board has, I think, never got adequate acceptance, and it has always seemed to me a very sound proposal that would go a long way to correct this problem.

I will now turn to another subject having to do with the training of scientists for military work or for the Atomic Energy Commission.

The most important stage in the training of scientists is in the graduate school where the candidate is working on fundamental problems in close association with active experienced scientists, getting a good deal of guidance at first and eventually becoming able to develop new things on his own.

This standard form of university training on jobs of fundamental importance needs to be considerably enhanced.

Now the Atomic Energy Commission, for instance, is very much concerned about increasing the amount of research done on the fundamental properties of materials. A great proportion of the AEC's scientific problems are those of materials in one way or another. If you could get materials with much higher ability to resist temperature and radiation and so on, many of the atomic energy problems would be assisted.

There has been, indeed, in recent years a rather considerable fundamental scientific breakthrough in our understanding of materials, through the physics of the solid state. There is a radical difference between our understanding of solids 10 or 15 years ago and what we have now, and the Atomic Energy Commission needs the development of this knowledge greatly enhanced for their practical purposes.

They will come, they have come to universities, and say, "What can you do to increase it? How can you increase the fundamental work on solids and materials?"

Curiously enough, this comes down not to manpower but to space. The universities, despite this very severe shortage of scientific manpower, are the most attractive place for real scientists to work, and we do not yet have difficulty in attracting the highest quality of manpower, the leading scientists. But every university in the country, I think, what with increasing enrollments, has a very severe space problem.

Several of them, not many months ago, said to the Atomic Energy Commission, who wanted this sort of work increased, "We cannot do it unless we have additional buildings in which to do it."

As a practical and more or less immediate thing, probably the building of buildings in which research in atomic energy or in the military fields could be done in the neighborhood of universities, could very greatly aid the amount of fundamental science in those fields which could get done.

Representative PRICE. You are talking about the contract you have with the Atomic Energy Commission?

Mr. LOOMIS. The scientific work would be done, presumably, under contracts with the Atomic Energy Commission or with the military. The money for the contracts comes easily, and the manpower, I think, is available. What is lacking is the space in which to perform the work.

Representative PRICE. You are saying it is becoming increasingly more difficult for the universities to accept additional assignments from the Atomic Energy Commission without something being done about expanding the facilities?

Mr. LOOMIS. That is right. Facilities are for many reasons a harder sort of thing for the Government to furnish than the awarding of contracts for research.

Finally, I would like to turn back to the matter of education, particularly in the elementary stages, and say that, if you consider the high schools, what is required for the development of scientists in the physical sciences is not so much physics or chemistry in the high schools, it is mathematics. Give the colleges a good preparatory training in mathematics to build on and we can do the rest. We would prefer to have some science, but without the mathematics we are lost.

I know that Prof. I. I. Rabi has spoken to this committee, and made what seems to me a very ingenious suggestion to correct this, which was scholarships awarded to students entering college if they had had an adequate amount of mathematics and had passed tests on it at the close of their high-school career.

This seems to me rather an ingenious invention, and I like it. It might do just the trick because it will serve to create the opportunity to have the mathematics without in any way forcing the student to make his selection for science.

If he gets good mathematics in high school and calculus the first year in college, they will do him good in almost any intellectual field, and he will then have the opportunity to make the selection of science as a career without having been forced to do it.

Representative PRICE. You represent the American Institute of Physics. It has been suggested by some they would include physics or chemistry in such examinations.

Mr. LOOMIS. I think the mathematics is more important.

May I say I do not represent the American Institute of Physics. I am a member of the Institute and various committees, but I am speaking solely for myself. This is not the organized opinion of the Institute.

Representative PRICE. Dr. Rabi specifically sought to exempt any specialized subjects in order to make it open to almost every student regardless of what he intended his course would be after he left high school.

Mr. LOOMIS. I like that. I agree with that, partly because the mathematics is so important.

Representative PRICE. In your reference a while ago, Doctor, to the universities trying to increase their work and finding it most difficult to work on assignments from the Atomic Energy Commission because of lack of facilities, were you referring to almost every contractor or to specific schools?

Mr. LOOMIS. The ones that I know about are a small group of the most effective institutions. There are perhaps a total of ten or a dozen which are used more than any others, and it was a selective group of those who are strongly in solid state work to which the Atomic Energy Commission came and asked us questions.

Representative PRICE. Could the Commission solve that problem by spreading out to other schools or would they also be in the same predicament?

Mr. LOOMIS. I think this space deficiency is universal.

If you wanted to accomplish, however, a specific result, such as good research in the physics of materials and metallurgy, you should go where the staff is strong in those fields.

Representative PRICE. You may proceed.

Does that complete your statement?

Mr. LOOMIS. That is all I have to say.

Representative PRICE. Thank you very much, Doctor. We appreciate your courtesy and the time you have given the committee this morning.

Mr. LOOMIS. Thank you.

Representative PRICE. The final session of the current hearings of this subcommittee on the shortage of scientific and engineering manpower will be held next Tuesday morning, May 1, at 10 a. m., at which time former Senator William Benton, chairman of the board of the Encyclopaedia Brittanica will appear with other witnesses to present testimony.

That concludes the morning's hearing, and the committee stands in recess until next Tuesday at 10 a. m.

(Whereupon, at 12:10 p. m., Thursday, April 26, 1956, the subcommittee recessed until 10 a. m., Tuesday, May 1, 1956.)

SHORTAGE OF SCIENTIFIC AND ENGINEERING MANPOWER

TUESDAY, MAY 1, 1956

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
SUBCOMMITTEE ON RESEARCH AND DEVELOPMENT,
Washington, D. C.

The subcommittee met, pursuant to recess, at 10:20 a. m. in the Caucus Room, Old House Office Building, Hon. Melvin Price presiding.

Present: Representatives Durham, Price, and Cole; and Senator Anderson.

Present also: George E. Brown, Jr., of the committee staff.

Representative PRICE. The committee will be in order.

This is a continuation of a hearing being held by the Subcommittee on Research and Development of the Joint Committee on Atomic Energy to hear testimony on the shortage of scientific and engineering manpower, particularly as it affects the atomic energy program.

We are privileged and honored to have as our first witness today the former Senator from the State of Connecticut, Mr. William Benton, publisher of the Encyclopaedia Britannica.

Mr. Benton, will you proceed with your statement.

STATEMENT OF WILLIAM BENTON, PUBLISHER, ENCYCLOPAEDIA BRITANNICA

Mr. BENTON. Mr. Price, I would like to precede my prepared statement by saying that I think your hearings are among the most important held during the year in Washington. I bewail the fact that they are not getting the widespread publicity they deserve. I have read many of the statements by witnesses before this committee, and they are excellent. I congratulate you on the witnesses you have had and congratulate the witnesses on their most constructive statements. Yesterday I complained about your lack of publicity to some of my newspaper friends in Washington, although of course I cannot say that this complaint will prove effective. Such efforts of mine have been ineffective many times before.

Representative PRICE. Thank you very much.

Mr. BENTON. I hope you won't be discouraged by the lack of publicity because you are dealing with a subject of very deep and vital concern to the American people.

Representative PRICE. We feel that we are performing a public service by putting into one record many fine recommendations and

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statements which are coming from the leaders of thought on this subject. We think this record will be a valuable document. While our hearings may not be attracting the attention that we might hope they would, we feel that the suggestions and recommendations which have been made will help to do something about correcting the problem we are facing.

Mr. BENTON. I had hoped that your committee would come up with specific recommendations for action and legislation. Isn't that in your mind?

Representative PRICE. That is in the background, although we did not go into the hearings with the definite purpose of writing legislation. We went into it to dramatize the problem which exists and to make it known to the people of the country, hopeful that through the testimony we received there might be suggestions that could or would lead to legislation which might be helpful in solving the problem.

Mr. BENTON. I have a suggestion for you this morning which would certainly help you dramatize the matter if you are in a position to heed it.

Representative PRICE. We certainly would like to have your suggestions.

Mr. BENTON. I am particularly pleased that Senator Anderson did me the honor to come this morning. I admire him for his leadership of this committee, as I have admired him ever since we had a chance to become acquainted when we served together under President Truman and when I used to appear regularly up here on the Hill before congressional committees during my service as Assistant Secretary of State. I am glad to see him in such glowing health.

Mr. Chairman, do you have the statement that I prepared for your committee? Perhaps I should skip parts of it as I run through it with you. Knowing the pressures under which you are working, if you will give permission to insert the whole statement, I shall merely skip through it.

Chairman ANDERSON. I would be particularly happy, Mr. Benton, if when you get to them you would dwell on your suggestions as to how this might be brought home. I spoke up in your State of Connecticut, in New Haven, not very long ago and used a great many examples of how parlous times were in scientific development. Afterward I happened to be discussing the subject with an individual there and reminded him that Russia was graduating more engineers and Russia was catching up, that it was possible that Russia had a great many fine developments. He looked at me and said, "One Einstein can overcome 100 of these Russians."

What he didn't realize is that Einstein didn't start in the United States. We had to import him, as we did a great many of the brilliant minds with which we have been blessed. I want to be sure we are able to grow our own crop.

Mr. BENTON. That puts the problem very well, Senator Anderson. We of Connecticut are always eager to welcome Senator Anderson to our State. One reason is that he is perhaps as well known there as in any State in the Union except his own, due to the widespread interest in Connecticut in this committee growing out of the speeches of my former colleague, Senator McMahon, up and down and across

the State over a period of years, during his chairmanship of this committee. I think you may find that we of Connecticut have a deeper interest in the area for which you are responsible, and more knowledge of it, than the people of other States. I hope that through your committee, this same kind of interest will be generated elsewhere.

Representative PRICE. If you don't object we will include your full statement in the record and you may proceed with the parts that you wish to highlight this morning.

(Mr. Benton's prepared statement follows.)

TESTIMONY OF WILLIAM BENTON, PUBLISHER, ENCYCLOPEDIA BRITANNICA

Mr. Chairman, I do not know how to begin my testimony better than by quoting your own words. In the preface to your committee's new report—Engineering and Scientific Manpower in the United States, Western Europe and Soviet Russia—your opening lines are these:

"It should be no secret that the United States is in desperate danger of falling behind the Soviet world in a critical field of competition—the life-and-death field of competition in the education and training of adequate numbers of scientists, engineers, and technicians. But although it is not a secret, the facts have not sunk into the public mind."

In these two sentences you went straight to the heart of the matter. If we Americans are to meet a radical challenge with a radical answer, our first need is to focus the gaze of the Congress and the public on the gauntlet that has been flung at us. Our first need is to arouse our people and our legislative representatives from their sleepwalking, to arouse them to the accelerating danger. Our second requirement is to hammer out the solutions.

Among those who have sought the facts, there is little disagreement about them. I cannot recall a post-Korean issue coming to the Congress where the facts, as distinct from policy, have been clearer. If there is disagreement about the facts, it is only as to whether they are alarming or catastrophic. Your committee's report seems to put Dean John Dunning of the Columbia University Engineering School in the latter camp. He said:

"As it stands, nothing can be done to prevent the Russians from gaining on us in scientific and technical manpower at a ratio of 2 to 1. Already we have lost the battle of engineering manpower—at least in numbers."

I have read British studies on Soviet professional manpower, and I have reviewed the impressive 400-page study by Dr. Nicholas DeWitt of Harvard which forms the basis of your committee's summary. In my judgment, and on the basis of my interviews with leaders of Soviet education, Dr. DeWitt is too conservative in his recital of Soviet achievements. I do not believe he gives sufficient weight to the mounting momentum of Soviet educational growth. The Soviet decision to make compulsory its basic 10-year school—to make this compulsory for all boys and girls from 7 to 17, thus adding three years to the former minimum—was decreed only in 1951. It is to be achieved by 1960. I was told in Moscow and Kiev that it is already 70 percent realized, with the full 10-year program now effective in all cities. There seemed to be little doubt that this will be 100 percent by the end of the current 5-year plan. This in itself will constitute an enormous spurt forward in the training of Soviet manpower.

Dr. DeWitt tells us the Soviets sometimes withhold figures, and sometimes change the statistical base unexpectedly, but that in this area at least, they never practice outright fraud. The figure I was given for enrollment in higher institutions—1,825,000—was about 100,000 higher than his. My figure on enrollment in the tekhnikums—2,500,000—exceeds his by about 800,000. My figures are somewhat more recent. They may indicate the accelerating momentum.

Questions of judgment enter here. Mr. Khrushchev announced in February that all tuition fees in the Soviet Union are to be abolished this fall. Is not this a still further indication of the Soviet drive to develop and exploit the full potentialities of its manpower? How far will such a drive succeed, and how rapidly? My judgment is that both the chance and the speed of success are higher than statistical tables could possibly reveal.

We want our statisticians, our experts, to be cautious, to provide qualifications and the footnotes, and to point up the exceptions. The task of statesman-

ship, the task of this committee, is to see the larger meaning, to interpret and propose and persuade, and to look ahead and guess the future and prepare the American people for it.

Your report shows that the number of trained engineers in the U. S. S. R. increased from 41,000 in 1929 to 541,000 in 1954—an increase of 500,000 in 25 years—or 1,300 percent. In the United States our increase was from 215,000 to 500,000 in approximately the same period—about 225 percent. Your report shows that the number of engineers graduating from Soviet higher institutes increased from 28,000 in 1950 to 63,000 in 1955. In the same period the number of engineering graduates in the United States plummeted from 52,000 down to 23,000. There is reason to believe the trend is being reversed in the United States. But there is no reason to believe it is being reversed in the U. S. S. R. Let us remember Mr. Khrushchev's exclamation to the people of India last December: "We shall see who has more engineers, the United States or the Soviet Union."

Soviet gains in the production of scientists, especially research scientists, are equally startling, though by comparison less dismaying.

How can these trends be dramatized so that we can produce the actions the crisis demands? Surely not merely through tables of figures in the smallest type of the Government Printing Office. The GPO could make Patrick Henry sound about as inflammatory as a tired dishrag.

Let us first ask, what accounts for public and congressional apathy? Why have the facts "not sunk into the public mind?" In part this may be because the administration keeps talking about the defeats it has inflicted on the Soviet Union. Mr. Dulles even hinted last year that the Soviets are on the verge of collapse. But there is a deeper reason. It is our American folklore. Our folklore says that Russians are either moody philosophers or crafty peasants. They don't know what to do with machines. Our folklore says that Americans are the world's greatest inventors and the world's best mechanics and gadgeteers; we subscribe to the belief that God gave us extraordinary talent for know-how. How can anyone learn to make or handle machines better than we Americans do; and especially, how can the Russians?

Everyone who has had to deal with public opinion knows it's easier to utilize folklores, and the clichés of folklore, than to change them. In this case we must change them. Only last month came a story from Moscow which gave me wry amusement, a kind of man-bites-dog story. A Texas corporation, no less, was granted the right to manufacture a Soviet turbodrill, no less. This drill was developed by the Soviet petroleum industry for digging wells through hard rock. The New York Times said it was "10 times as fast as our conventional rotary drill." Detroit engineers report automation matching our best. Each day and week there is a new story of Soviet technological advances.

When I was Assistant Secretary of State 10 years ago the Soviets were entering a particularly chauvinistic phase. They were laying claim in their world propaganda to one great invention after another, most notably radio. We wondered when they would claim credit for baseball. I wrote to my editor-in-chief at Britannica. Mr. Walter Yust, a good Taft Republican who reads the Chicago Tribune every morning, and asked, what about these claims? He replied, in effect, let's not discount them without examination. He reminded me of the scientific tradition of the 19th century Russia. He reminded me that in the first decade of the 20th century more world patents were applied for by Russian inventors than by the inventors of any other nation. The Russian economy wasn't then capable of developing the inventions, so the Russians tended not to get the credit. Gentlemen, there's no doubt that the Russian economy today, which is expanding at a much more rapid rate than our own, is capable of developing its own—and other people's—inventions.

Further, some people have liked to delude themselves by explaining away Soviet advances in nuclear explosives and nuclear energy, and in the development of guided missiles and in other fields, as the achievements of captured German scientists, or as due to espionage. Others have deluded themselves by placing too great weight on the deadening effect of political dogmas or interference on scientific thought. The degree to which the scientists and engineers have been imposed on by the politicians has in my view been greatly exaggerated. Many Soviet engineers and scientists are not members of the party. The Marxist-Leninist dialectic does not impinge itself on the physical and mathematical sciences—at least to any degree that bothers a creative scientist. The most spectacular example of such interference in biology, the Lysenko theory in genetics, now seems headed for the ashcan.

Finally, some people may like to console themselves with the thought that the quality of Soviet scientific and technical education (training is perhaps a better word) is inferior to ours. The curriculum of the Soviet 10-year school should explode that myth—if we can get our people to listen: 5 years of physics, 5 years of biology, and 4 of chemistry compulsory for all students; 10 years of mathematics, up through trigonometry, and 1 of astronomy, compulsory for all.

I saw at first hand something of the rigor and discipline of the Soviet school system—the long hours, the 6 days a week and 10 months a year at school, the vacations which include compulsory work in factory or on farm, the frequent and searching examinations.

The contrast with our own primary-secondary-school curriculum is startling. Lewis Strauss, Chairman of the Atomic Energy Commission, recently told the Thomas Alva Edison Foundation: "I can learn of no public high school in our country where a student obtains so thorough a preparation in science and mathematics, even if he seeks it—even if he should be a potential Einstein, Edison, Fermi, or Bell." What Admiral Strauss is saying amounts to this: Every youngster in the Soviet Union gets a better scientific grounding than any youngster in the United States. As an aside, I point out to the committee that, with our long summer vacations, dating back to the days when the young people were needed for work on the farms, and with our light schedules of academic work, we keep the youngsters in public school for 12 years and achieve far less than the Russians and other Europeans do in 10. (A quick way to relieve the teacher shortage would be to squeeze two needless years out of our system; and this, with a 10-month school year, would make it very easy greatly to raise the salaries of competent teachers, even on present budgets.)

At the level of higher training in the U. S. S. R. we have Dean Dunning's statement that "on the master's and doctoral levels they (the Soviets) appear to have been giving degrees to probably three or four times as many as we have."

Out of the 67 members of the Council of Ministers of the U. S. S. R., 39—more than half—have had a scientific or technical education. Mr. Yelutin, the Minister of Higher Education, whose ministry controls the 33 Soviet universities and shares control of the 800 or more technical institutes, is a metallurgist.

Let me now add a new dimension to the urgency of the problem posed for us by the new Soviet threat—a dimension you would scarcely deduce from studying the mere statistics. Manifestly we are worried because technology can change the balance of military power. That is worry enough. Further, we are worried because technology, through its impact on heavy industry, can change the world balance of economic power.

The problem, however, is wider and deeper than both these concerns suggest. These two apprehensions, though they are real enough, do not sufficiently take into account the new Soviet tactics of "competitive coexistence." I have seen no comment—other than my own cries of distress—about what the rise of Soviet science and technology is doing and can do to the "psychological power balance." I am not fearful that the Soviets will outdo us in the export of automobiles, or tractors, or business machines; these earn for us not only money but envy. I am upset about the Soviet talent and capacity for exporting ideas. They are today producing almost three times as many new engineers as we are, yet their own industrial capacity is still only half the size of ours. What will happen to this growing crop of trained men? Bulganin at the 20th Soviet Congress in February said that under the new 5-year plan, 4 million graduate technicians would pour out of Soviet institutions, as many as under the last two 5-year plans put together. Where will they go? Most assuredly a substantial block will be exported. Every graduate, as at West Point and Annapolis, is, for the first 3 years, under orders from the state, which paid for his education. The Soviet scientists, engineers, and technicians can be sent anywhere in the world, just as though they were frontline troops. The countries of Asia, Africa, and Latin America are hungering for the knowledge and know-how these men command.

The new propaganda of the Kremlin, emphasizing economic, political, and ideological competition, clearly reveals the long-range Soviet plan—a plan so potent as to make military maneuvering seem by comparison tactical and even diversionary. Central to it is this schooling for export of scores of thousands of indoctrinated and capable engineers, scientists, schoolmasters, and technicians of all kinds. These are being trained to help convert the world to communism. In Burma last December Khrushchev and Bulganin offered to build and staff a technological institute in Rangoon, "a gift to the people of Burma from the people of the Soviet Union," as they put it. An advance guard of technicians

is now in India, in connection with the steel mill the Soviets are building for India. A technical institute has also been offered to India, and enticing inducements have been advanced to Egypt, Afghanistan, and Latin America.

Did you notice that 6 years of foreign-language study is compulsory for every Russian boy and girl in his first 10 years of schooling, and that further foreign language study is required in higher education? I was astonished in Moscow to learn that there are some schools where all the teaching is conducted in a foreign language. Thus, my son John, age 13, visited a school in Moscow where everything except Russian literature is taught in English. The name of this school is "Moscow School No. 1." English, by the way, is the favorite foreign language. It is the new language of science and gives access, with Russian, to the world's scientific literature.

I have a suggestion to you this morning on how you can begin to convey some sense of the urgency of this new problem—at least to your colleagues here on the Hill. You aren't likely to do it with statistics. Even though I had spent weeks preparing for my trip of last fall, including two weeks in London, I was aroused myself only by my firsthand exposure to what is going on.

On my first day in the Soviet Union I toured the huge Lenin Library in Leningrad. I gathered that I was the second American since the war to visit it. Its director claims it houses 12 million volumes. Every desk and chair in the great reading rooms adjacent to the scientific stacks was occupied; the silence was absolute; the concentrated zeal of hundreds upon hundreds of earnest-looking students was to me a bit breathtaking. I said to my librarian-guide, "Are these students from the university?" "Oh, no," he replied, "the university has its own library; these are workers from the night shifts of the factories, and by night our reading rooms are crowded with those from the day shifts. We operate day and night. This is how the workers prepare for examinations for advance training in the universities and the institutes."

One sees youngsters in their midteens, and young Russian married couples, in the bookstores browsing at the sections featuring scientific works; they buy books on nuclear physics in preference to novels or handbooks on interior decoration. This is how to get ahead in Soviet society today.

In Moscow I spent several hours with the prorector of the University of Moscow, Professor Vovchenko, a chemist. The university which enrolls 23,000 students, dominates the city. Its gleaming new 33-story central tower is dedicated to the sciences. The recent investment of 3 billion rubles for this new building, completed in 1953, is astonishing by our standards. It is equivalent to at least $150 million, figuring the ruble as 5 cents, the lowest estimate of its value given anywhere. Thus this building cost more than has been spent for the complete physical plant of all but a very few American universities. It contains 1,900 laboratory rooms. It symbolizes to all Russia what lies ahead in the fulfillment of Soviet ambitions for youth. Here work most of the 2,000 professors of the University of Moscow who teach students. Here, too, are the 500 scholars dedicated to research, from whom no teaching is expected. All 2,500 must seek to make their own individual scientific contributions in the laboratories. If they don't, they are fired. Those who succeed receive the higly prized doctorate, a top or super degree for which we have no equivalent. The impact of that structure, which can be seen from everywhere in Moscow, and the busy life within it, can convey the sense of urgency far more vividly than most statistics.

In Kiev I visited a tekhnikum. Dr. De Witt estimates there are some 3,700 tekhnikums in the U. S. S. R. They are a unique Soviet institution—a kind of vocational college producing "middle trained" specialists. For example, a tekhnikum maintained by the Ministry of Health will produce "feldshers," graduates about halfway between the level of a nurse and a doctor. The tekhnikums give 4-year courses for those who have finished 7 primary and secondary grades, or 2 or 2½ year courses for those who have completed the 10-year school. Soon all tekhnikum students will be 10-year graduates.

My Kiev tekhnikum is one of 50 maintained throughout the Soviet Union by the Ministry of Coal and Coke. It is a sprawling brick building, not very different in appearance from a large city high school in the United States. As with too many of our own big city schools, the overall effect of the exterior is dingy.

The director told us that his tekhnikum, of which he was immensely proud, taught courses in four special fields of coal mining: the construction of coal mines, the construction of coal mine buildings, roadbuilding for coal mines, and the construction and use of communications equipment in coal mining.

Eleven years ago his school had only 255 students. Now it has 2,500 and faculty of 88.

He bustled us down a hall and into a laboratory. Here the machines began and the shabbiness ended. The laboratory was stocked with expensive machinery and electric models of coal-mining equipment. Some of the models, the director said, were made by his students. The more elaborate ones had been built to order at factories, with parts of the operating mechanism visible through openings in the sides.

The department head had been warned of our coming, and was eager to show us how each of his models worked. Oozing confidence and enthusiasm, he led us to laboratory after laboratory. The variety and excellence of the equipment astonished me. Surely few if any of our own technical schools can match such equipment. Manifestly it was worth hundreds of thousands of rubles, and the director went so far as to place the value at millions. I think he was right.

In another laboratory, there was a large and detailed model of the entire transportation system of a modern mine, including a complete electric train. Another showed a mine's complete electrical system, and still another showed a telephone system, switchboard and all. There was a 50-foot long coal combine, a huge machine that eats its way right into the face of the coal, picks it up, cuts it in chunks and carries it away. One room, more than 50 feet long, had 40 or 50 big machines lined up along the walls, something like pictures on the walls of a museum, many equipped with elaborate dials and meters. Again, the department head wanted to push all the buttons for us.

The problem of getting students to apply voluntarily for a coal-mining tekhnikum interested me because I don't believe that coal mining, even at the technician level, is exactly popular as a career in the United States. The director intimated that this problem is solved by propaganda and promises. As he put it, the graduates of the 10-year schools are "guided" into specific tekhnikums by what he called the process of popularization. This is a fine Soviet propaganda phrase designed to obscure the fact that the students have far less choice of fields than they may think. By incentives and scholarships, as well as "popularization" in the form of the propaganda of the various ministries which operate the tekhnikums, the students are siphoned into aeronautical engineering, let us say, instead of into history (where scholarships are rare).

The director of the Kiev tekhnikum told us that the graduates of his school would be sent to the coal mines, perhaps in the Donetz Basin of the Ukraine, where an alumnus might work as a foreman or in any number of supervisory positions. We had an appointment with the mayor of Kiev, but our tekhnikum director was gladly prepared to make us late for it. Again and again he delayed our departure, insisting that we seek "just one more room, just one more laboratory." Even when we finally made the break, explaining that we had only 4 minutes in which to drive across the city to meet the mayor, the director was still saying, "just one more."

That episode left me with more sense of urgency than most statistics possibly can.

So here is my proposal: I urge the entire membership of this subcommittee to go to the Soviet Union and see for yourselves. Let us apply for visas which put to the test "the spirit of Geneva," the new Soviet propaganda slogan which was being hammered in all media when I was in Russia. Apply for the visas now, so that you will be sure to have them by the time Congress is ready to adjourn. Take some key members of the Appropriations Committees, along with you. Visit the Ministries of Education and of Higher Education, and the various government ministries which finance the technological institutes and the tekhnikums. Visit the universities, and the technical institutes, and the 10-year schools. Talk to the students, and watch them at work. You will come back prepared to convey that sense of urgency which is so urgently necessary. You will also come back with some very good speeches, perhaps even some campaign issues.

Ten years ago, as Assistant Secretary of State, back in the days when there were only a few Assistant Secretaries and we thought we amounted to something, I was trying to create our Nation's first peacetime program of international information. I faced the same kind of apathy—indeed the same kind of folklore: "propaganda" was a horrid word, and Americans didn't practice it. Further, after the 1946 election of the 80th Congress, my operation became a party issue. I was told that I didn't have the basic legislative authorization. And I didn't have the understanding attention of the Appropriations Committees. So I went from office to office up here on the Hill, arguing that the committees involved should go abroad and appraise the problem, and appraise for

themselves the need for our operation. They did so, and I believe that is the chief reason the Smith-Mundt Act was passed. At the time I was told that my efforts blazed the path for the subsequent and widespread practice by committees of the House and Senate of making study-trips abroad. With the aid of a few friendly editorial writers, I helped kill the journalistic idea that such trips were junkets. The word stayed dead until the ill-fated Cohn and Schine.

What should you then seek to do, once the acuteness of the problem has broken through into congressional and public consciousness I have a few suggestions which I do not pretend are comprehensive or adequate, but which are at least a very good beginning.

We cannot duplicate in this country the full array of pressures and incentives the Soviet Union is able to bring to bear on its young people—and we wouldn't want to duplicate it if we could. Theirs is a highly centralized, push-button system. The curriculum is standardized throughout the Soviet Union right up to what we would call the graduate school level, with only one basic choice open to the student, the seeming choice of a career which he makes at the end of the 10-year school. If he's bright enough and is well advised, he will aim at maximum training which brings not only rich rewards but also draft exemption.

To the usual incentives of patriotism and of pride in national progress, Communist leaders have added most tangible allures to prospective scientists and engineers. They have made the life of science among the most satisfying in the Soviet Union.

A typical Soviet professor gets 6,000 rubles a month, 10 times the average workman's 600 to 700 rubles. An *outstanding* Soviet engineer or research scientist can earn up to 40,000 rubles a month, when his outside consulting fees are included. In comparative standard of living, this would put him in the class of big-time American corporation presidents. Indeed, how many corporation presidents earn 70 or 80 times as much as their file clerks? The contrast has been so extreme in the Soviet Union that a dispatch in the New York Times last week reported that the big pay and perquisites are going to be reduced. But we can be sure they will still provide plenty of incentive to the scientists and engineers.

Mr. Chairman, I want to quote once more from your own preface:

"I recognize (you say) that the question of general Federal aid to schools is a controversial subject * * * I suggest we could reach agreement that, since it is a constituted Federal function to provide for the common defense, Federal spending is proper to provide enough well-trained engineers and scientists to sustain our security in an age of great scientific 'breakthroughs'."

Mr. Chairman, no one who has looked into this momentous problem can quarrel with that proposition.

I have mentioned the developing Soviet program to use its engineers to outmatch our technical assistance program—our point 4. Yet, according to my information, the United States is finding it increasingly difficult to persuade qualified people to go abroad on our technical aid missions. And indeed, why shouldn't a young engineer prefer to build his career in Bridgeport or Topeka, rather than in Kabul or Jakarta? Why indeed? If your son were an engineer and he were choosing between Pratt & Whitney in Connecticut or the Irrawaddy River of Burma—which choice would you advise if you wanted him healthy and wealthy?

I suggested one answer to this national problem at the memorial luncheon this year for former Secretary of War Patterson, known to many of you. That is the creation by the United States Government of technical assistance academies, comparable to the United States Military, Naval, and Air Force Academies, but designed to produce foreign-aid specialists. In the Journal of the Foreign Service Association I read recently of a proposal for a career service in technical assistance. Of this I am doubtful, but my proposed academies should require 3 years' service overseas from the graduates, in return for their free education, and from such beginnings I agree that a career service could develop. These technical academies or institutes should be operated in conjunction with existing high-level institutions, such as MIT and the California Institute of Technology. The entire student body should be fully supported while in school, and be given a special status under the draft such as reserve commissions on graduation.

These "West Points of Point Four" should teach not only engineering and technical subjects adapted to the needs of underdeveloped nations. They should

include emphasis on the recognition of human values, including the use of educational techniques, and they should insist on a thorough grounding in liberal arts designed to help graduates to become symbols and spokesmen abroad of our concepts of freedom and justice.

West Point was founded, and was sustained in its early years, not only to provide an officer corps for our Army but to train the engineers needed for the development of the West. Wasn't it our first engineering school? Would we even have had it when we did without the crying need of the West for engineers?

I concede that a chain of such academies would serve only a limited function, measured against the problem posed by the Soviet threat. Further, I concede that the institutes would take time to build and that we must promote a program at once.

What we require today, and at once, as Chairman Price says, is a "crash program." How can this be launched, and at once? It seems to me that the beginning of such a crash program must consist of Federal scholarships on a dramatic scale.

Last month in Chicago, before the Association for Higher Education, I proposed a national competitive scholarship program beginning with 20,000 scholarships a year, each covering 4 years of college. I further proposed that this number should be increased as rapidly as the administration of the program and the absorptive capacity of the colleges and universities permit—to a level of 100,000 scholarships a year. To these should be added 20,000 or more graduate fellowships. Trained manpower, I said, is like money in the bank for the United States. It is our most important national resource. Premier Bulganin referred to Soviet trained manpower as "our (Soviet) gold reserve."

Our United States high schools abound with talent worthy of such scholarships. Secretary Folsom recently cited an estimate that "each year about 60,000 students of high ability drop out of high school before graduation * * * and half of the students in the upper one-fourth of their high-school classes do not go to college." Dr. Dael Wolfle tells us that 150,000 pupils from each yearly age and class who could enter the important specialties fail to go to college. About half fail to go on because of the cost, another half because of lack of incentive. Both conditions are curable. All who look into the matter agree that for every student in an American college, we have another of equal ability who doesn't get in. Of the top 20 percent of our high-school youngsters, two-thirds don't finish college. In my judgment, the main reason is economic.

We would be perfectly justified, in view of the emergency we have been discussing, in earmarking a proportion of any proposed Federal scholarship program for science or engineering, or indeed even of initiating the far larger program with scholarships and fellowships limited to the areas we are discussing.

When I mention priorities for scientists and engineers I don't for a moment mean to suggest that more scientists and more engineers will solve our problems. For our national defense, and our national well-being, we need better educated citizens in many fields—political scientists, historians and psychologists, for example—and we need them as much as or possibly even more than we need engineers. I am willing to give engineering, physics, and chemistry a short-run priority because there is an emergency shortage in these fields. But I fear the dangers in a lopsided program of Federal aid, one which is geared too heavily to the sciences. I have just seen figures on the first 359 boys who have won the newly established national merit scholarships. The boys were chosen without regard to career choice. They rate for the moment as our "brightest boys." They won the philanthropic jackpot comparable to the $64,000 question. Sixty-three percent of them now choose engineering and scientific research as their future careers. Let us not ignore the danger that too high a proportion of our best young talent can be funneled into science and engineering. They are needed elsewhere at least as much.

I realize there are many complications in my Federal scholarship proposal. Who should administer the scholarships? One of the most significant steps taken by the Congress in this area in recent years has been the establishment of the National Science Foundation. Its budget, however, is far too small. It is today supporting about 2 percent of all graduate students in science, mathematics, and engineering. Whether it should attempt to administer a huge program at the undergraduate level I cannot say.

I have a further immediate suggestion. I heard recently that only 125 new teachers of physics were available last year for the 28,000 high schools of the United States. The reasons are several, but I believe a partial cure could be achieved by paying substantially higher salaries to high-school teachers of mathe-

matics and the natural sciences. If mathematics and the sciences are harder to learn, and harder to teach, why shouldn't the teachers in those fields get higher salaries? And should they not be exempted or deferred by selective service? If a young man is more likely to secure exemption or deferment as a physics teacher than as an English teacher, or than as an employee of General Electric, will we not secure more high-school physics teachers?

My comment here is subject to the same qualification I made about scholarships. I believe we must come in the long run to Federal assistance of teachers in many fields.

Mr. Chairman, many other proposals could be made. I happen to be chairman of a company that makes classroom motion pictures, Encyclopedia Britannica films. You would be dismayed to see how slowly the educational world adapts itself to advances in the technology of education itself. And as Mr. Philip Coombs, research director of the Fund for the Advancement of Education, told you in testimony last week—the possibilities in bringing technology to the classroom are "wonderful to contemplate."

Another grave problem is the control exercised by teachers' colleges, which some call monopolistic. An honors graduate in physics from Yale cannot teach physics in the public schools of my home State of Connecticut until he has earned a certificate from a State teachers college. Neither can a Princeton physics cum laude, in New Jersey. These are problems you no doubt regard as outside your power or purview.

Let me conclude with this thought: Education is one area where we in America most surely have nothing to lose if we accept Soviet claims and the Soviet challenge. Intercontinental competition in education need be no challenge to an arms race or a war. If the Russions goad us to do a better educational job ourselves, then we shall only do what our own best tradition calls for—what we should be doing even if the Soviet Union were to sink suddenly into the sea. But if we are complacent about our educational efforts and system, if we allow ourselves to fall behind the Russians, we may find ourselves outwitted, outmaneuvered, outthought, and outbuilt throughout the world.

Mr. BENTON. I wonder, Senator Anderson, if you noticed the picture featured by the papers a few days ago of Khrushchev and Bulganin leaving England. They were waiving good-bye at the rail of the boat. Right next to them and waiving on a par with them was the man who invented the new Soviet jet bomber. And who was the fourth man in the picture? The great Russian atomic scientist who had come along with them. These two extra men thus featured almost as coequal partners as they departed from England, are symbols of what is going on in Russia today. That, in itself, if a picture is supposed to be worth a thousand words, dramatizes better than words can what is going on in Russia today from the standpoint of the safety and security of the peoples of the Western World.

Chairman ANDERSON. At the same time the heads of a great number of American universities in the Mural group were down here trying to get some money for a very advanced idea of an accelerator which might catch us up with the Russians. They were having extreme difficulty getting to see anyone above the custodial group.

Mr. BENTON. I had to go to the U. S. S. R., Senator, to find out that these new men of technology and science are the new Soviet plutocracy. These are the men, the inventors and scientists, and engineers who have the big apartments in town, the dachas and vineyards in the country, the cars and chauffeurs, right along with the members of the Presidium. They are treated in a material sense the way we treat our big corporation presidents.

May I now refer you to the first page, Mr. Chairman, to the last paragraph. [Reading:] Among those who have sought the facts, there is little disagreement about them. I cannot recall a post-Korean issue coming to the Congress where the facts, as distinct from policy,

have been clearer. If there is disagreement about the facts, it is only as to whether they are alarming or catastrophic. Your committee's report seems to put Dean John Dunning of the Columbia University Engineering School in the latter camp. He said:

> As it stands, nothing can be done to prevent the Russians from gaining on us in scientific and technical manpower at a ratio of 2 to 1. Already we have lost the battle of engineering manpower—at least in numbers.

I have read British studies on Soviet professional manpower, and I have reviewed the impressive study of Dr. Nicholas DeWitt of Harvard which forms the basis of your committee's summary. In my judgment, and on the basis of my interviews with leaders of Soviet education, Dr. DeWitt is too conservative in his recital of Soviet achievements. I do not believe he gives sufficient weight to the mounting momentum of Soviet educational growth.

[Interpolation:]

As you know, Mr. Chairman, a scholar who goes wrong in presenting his facts is likely to damage his reputation, and thus it is often wiser for a man building a reputation for scholarship to err on the conservative side. This is a difference in the problem of the scholar and the problem of the legislator or the problem of the policymaker.

[Reading and interpolating:]

The Soviet decision to make compulsory its basic 10-year school, just to take one example, to make this school compulsory for every boy and girl from 7 to 17, thus adding 3 years to the former minimum, was decreed only in 1951. Even the 7-year school was made compulsory, I was told only after the war. Around 1945 the Soviets made the 7-year school compulsory; and in 1951 the 10-year school. This shows the rapid acceleration of their drive for advancing standards of training and education.

In one of my speeches since I have returned from the U. S. S. R. I said the Communists gave up butter for guns, and this we knew, but I said further that they had given up meat for education.

On the next page of my prepared testimony which you have just put in the record, in the second paragraph, Mr. Chairman, I try to make the point I have just touched upon.

We Americans want our statisticians, our exports, to be cautious and to provide our policymakers with the qualifications and the footnotes, and to point up the exceptions. The task of statesmanship, the task of this committee, is to see the larger meaning, to interpret and propose and persuade, and to look ahead and guess the future and prepare the American people for it.

Not realizing before I came down, Mr. Chairman, the limitations from the standpoint of legislative proposals that perhaps have been put on your committee, I had hoped that you might come up with concrete and specific legislative recommendations. This was what I meant in my prepared statement about guessing the future and preparing the American people for it.

Representative PRICE. It is entirely possible that we will, on the basis of the many helpful suggestions which have been made here. There does appear some likelihood that there is a field here for Federal legislation.

Mr. BENTON (reading and occasionally interpolating): On page 4: Let us first ask, What accounts for public and congressional apathy?

Why have the facts not sunk into the public mind? Why are this committee's hearings not getting any publicity or public attention? In part, this may be because the administration keeps talking about the defeats it has inflicted on the Soviet Union. Mr. Dulles even hinted last year that the Soviets are on the verge of collapse. But I think there is a deeper reason than this, and I call it our American folklore. Our folklore says that Russians are either moody philosophers or crafty peasants. They don't know what to do with machines.

Senator Anderson has just illustrated this point in his little story, Mr. Chairman, the idea thrown at him that one Einstein is worth a hundred Russians. Your committee could not have a more perfect illustration of my point than Senator Anderson's anecdote from New Haven.

[Reading and interpolating:]

Our folklore says that Americans are the world's greatest inventors—that is why Senator Anderson had to remind his New Haven friend that Einstein was born abroad—that we are the world's best mechanics and gadgeteers. We Americans subscribe to the belief that God gave us extraordinary talent for know-how. How can anyone yearn to make or handle machines better than we Americans do; and especially, how can the Russians?

Everyone who has had to deal with public opinion knows it is easier to utilize folklores and the clichés of folklores than to change them.

Only last month came a story from Moscow which gave me wry amusement, a kind of man-bites-dog story. A Texas corporation, no less, was granted the right to manufacture a Soviet turbodrill, no less. This drill was developed by the Soviet petroleum industry for digging wells through hard rock.

Chairman ANDERSON. Incidentally, the industries who are doing it have been announcing a great expansion in their business, and so forth, and part of the expansion program is to make use of this remarkable new tool for drilling wells.

Mr. BENTON. I didn't know that. I don't see how we can fail but be impressed by such strides in Soviet technology, in view of our pride in our great oil industry, when the Soviets show up with a turbodrill that is 10 times as fast as our conventional rotary drill.

Chairman ANDERSON. I merely want to point out that the Russian industries are not a backward group. They are trying to develop techniques in the oil industry which will completely change the cost of drilling a well. Here we are happy to do it by taking the Russian invention.

Mr. BENTON (reading and interpolating). At the end of the next paragraph, Senator Anderson and Mr. Chairman, I point out that in the last century the Russian economy wasn't then capable of developing its inventions. The Russians often didn't get credit for their achievements in the last century because they could not develop them as scientific achievements. But there is no doubt that the Russian economy today can develop them. It is expanding at a much more rapid rate than our own and it is capable of developing its own inventions and other people's inventions also.

On page 6, the second paragraph, Mr. Chairman: Some people like to console themselves with the thought—these are the people that Senator Anderson was speaking of in New Haven—console themselves

with the thought that the quality of Soviet scientific and technical education is inferior to ours. The curriculum of the Soviet 10-year school should explode that myth if we can get our people to listen. By 1960, for every Russian child, this curriculum is to be compulsory: 5 years of physics, 5 years of biology, 4 of chemistry; 10 years of mathematics, through trigonometry, and 1 of astronomy.

Chairman ANDERSON. Where did you get that information?

Mr. BENTON. From Admiral Strauss at the Atomic Energy Commission, who gave this in a speech before the Thomas Alva Edison Institute. I used this in a speech before the Association for Higher Education which I sent to Mr. Allen Dulles, and Mr. Dulles wrote me, and I have his letter here with me.

"My experts in the field regard your treatment as both comprehensive and accurate."

Representative PRICE. What is the date of that letter?

Mr. BENTON. The 7th of April, 1956.

Yesterday I went in to see Mr. William Carr, the head of the NEA, about this whole problem before your committee because I am so aroused about it. It is one of the dire crises we Americans are facing, and perhaps the most serious. I asked Mr. Carr, a top expert on such a question, "Is it true that in the entire United States we trained only 125 teachers of physics last year for 28,000 American high schools?"

Mr. Carr said, "That is true. These are our statistics." Think of it, 125 teachers of physics for 28,000 high schools.

Admiral Strauss reports that 53 percent of our high schools don't have any physics teachers. Of course that percentage must be going up all the time if we train only 125 teachers a year.

What does the average American youngster do about physics? Only 4 percent take any physics at all. If he takes 1 year of physics, isn't his attitude, "There is my science."? I feel I know this because my two daughters are freshmen in college this year and they both dropped freshmen biology because it was too tough for them.

By contrast, I saw at first-hand something of the rigor and discipline of the Soviet school system—the long hours, the 6 days a week and 10 months a year at school, the vacations which include compulsory work in factory or on farm, the frequent and searching examinations.

Here I quote from Admiral Strauss: "I can learn of no public high school in our country where a student obtains so thorough a preparation in science and mathematics, even if he seeks it."—this is in contrast to any Russian child—"even if he should be a potential Einstein, Edison, Fermi, or Bell."

What Admiral Strauss is saying amounts to this: Every youngster in the Soviet Union gets a better scientific grounding than any youngster in the United States.

As an aside, I point out to the committee the long summer vacations of our American schoolboy, dating back to the days when the young people were needed for work on the farms. I asked Mr. Carr about this yesterday afternoon. I said, "Won't you agree that the long summer vacation is out of date, that it is obsolete, because our youngsters aren't needed on the farms any more?" When my mother was a 13-year-old girl in Iowa she was teaching school to boys of 16 who worked on the farms 9 months a year and came to school only in December, January, and February. Those were the days when every

child was regarded as a valuable asset to a farm family, when a widow with 4 children had a dowry more valuable than undeveloped land.

Chairman ANDERSON. Don't you regard as one of the really important points the necessity for giving our youngsters more work in school rather than less leisure time? Six days a week, 10 months a year.

Mr. BENTON. Senator Anderson, I asked Mr. Carr about this yesterday. He pointed up some of the difficulties and problems I hadn't thought about. He's a top professional. Admiral Rickover has proposed adding a month to the school year. I feel that at least a month ought to be added to the school year. The youngsters in my community sit around all summer with nothing to do, and many of them are a disgrace to the community. It would be a public as well as private service to get the children in my community into school for longer periods, and not only more months but more days per week and more hours per day. How serious the objection to the 6-day week would be never occurred to me until I asked Mr. Carr about it yesterday, and on this point I hope he's wrong. Offhand, to one who isn't a professional, and who isn't exposed to the problems in depth, this would seem to cut the requirements for teachers by one-sixth, and thus to relieve the acute shortage.

One quick way to relieve the tragic teacher shortage would be to squeeze 2 needless years out of our system; and this, with a 10-month school year—and a 6-day week—would make it easier greatly to raise the salaries of competent teachers, and even on present budgets.

Mr. Carr pointed out that the Jews would object to going to school on Saturday, that there is thus a religious objection to having a 6-day week. How serious that may be I don't know. Perhaps it would be an overwhelming argument against such a change in New York State, Connecticut, and certain other States, but I wouldn't think it would be an overwhelming argument against it in New Mexico. I just don't know the depth of that problem. The idea had never occurred to me until yesterday afternoon. But there is no doubt that the daily hours could be longer. Mrs. Benton and I are sending our youngest son, 13 years old, away to boarding school next year because he is on only a half-day schedule in the Fairfield, Conn., high school. Going to school half a day we think is not healthy. I find to my great surprise that it is now hard to get into any private school in New England. Education is one of our major businesses up in New England and I try to keep in touch with it for this reason among others. It may be that a lot of parents are having the same experience we are having in Fairfield and that may help account for these long waiting lists. Our public schools are deteriorating and disintegrating. There aren't enough of them. General Electric is hiring the physics teachers. The one solution for a well-to-do family is to deprive itself of a child, when the mother and father want to keep him at home, and to send him away to school even when the parents don't want to. In this round-about manner some of us are coming to grips with one of the most important questions facing the American people.

If you will turn to page 8 (reading):

The problem is wider and deeper than both these concerns suggest. These two apprehensions, though they are real enough, do not sufficiently take into account the new Soviet tactics of "competitive coexistence." I have seen no comment about what the rise of Soviet

science and technology is doing and can do to the "psychological power balance." I am not fearful that the Soviets will outdo us in the export of automobiles or tractors or business machines. These earn for us not only money but envy. I am upset about the Soviet talent and capacity for supporting ideas. They are today producing almost three times as many new engineers as we are, yet their own industrial capacity is still only half the size of ours. What will happen to this growing crop of trained men? Bulganin at the 20th Soviet Congress in February said that under the new 5-year plan, 4 million graduate technicians would pour out of Soviet institutions, as many as under the last two 5-year plans put together. Where will they go? Most assuredly a substantial block will be exported.

You will remember, Mr. Chairman, when Bulganin and Khrushchev left Burma, in their final speech they said, "We give the Burmese people as a gift from the Russian people a technological institute to be fully staffed by Russian technicians." They have made the same offer to India. This is the wave of the future. When we are debating $4.9 million for economic aid, we ought to be also debating the training of men to go with the economic aid.

Representative PRICE. It is evident that their production of scientific and engineering manpower is to them also a political weapon as well as a means of stepping up their own domestic production. They fully intend to use these people in a political way.

Mr. BENTON. You put it very well, Mr. Chairman. Your phrase "political weapon" nails it right down. Every Russian boy or girl is at the order of the State for 3 years after he finishes his education. Nobody complains about this. This isn't so radical. These young people respond just the way our West Point and Annapolis graduates do. "The State has given me an education and I owe them the 3 years." They must go wherever they are sent.

Not that they have too much liberty after the 3 years, but after the 3 years if they have studied hard, they can take their examinations and try to get into a university. They can hope to qualify for the graduate work to develop as scientists and scholars and to win the dachas, and so forth.

I had an interesting personal experience, which bears on this point, in Leningrad. On my first day in Russia I visited the great Leningrad library. I was the second American to visit it since the war. I entered the great reading room adjoining the scientific section, and every desk was occupied with a student, a pile of books, a little light, with the student taking notes. My librarian guide and I walked in. Not a student looked up. I have never seen more concentrated zeal. There must have been 200 or 300 desks. I said to the librarian, "I didn't know that your library was connected with the university." He said, "Oh, no, we are not." This was half past 11 in the morning. I said, "Aren't these university students?" He said, "Oh, no. The university has its own library. These are workers on the night shifts in the factories. We keep the library working 24 hours a day. At night we will be open for the day-shift workers."

I then asked the pro-rector of the university of Moscow about this. He said, "Yes, a high percentage of our top graduate students are those who have finished the 10-year school or the tekhnikum or the institute or the college in the university and then have gone out for

their 3 years and have continued their nightwork and study and who then have come back and taken the examinations and enter or reenter the university and thus go up to the top in the Russian scientific world."

You can understand that, Mr. Chairman, because hard and applied study of science and technology is the sure way to get ahead in Russia. You can't marry the boss' daughter as some young men fortunately do in Western Europe or even in the United States. There are no young Henry Fords who inherit a big factory. Concentrated application to one's books is the sure way to get ahead in the U. S. S. R. The Russians did not invent this. My Scotch friends have all known this. Any really bright boy in Scotland, for centuries as far as I know, has been able to win a scholarship and go through the university. My Jewish friends know this. This is the attitude so many of them have toward their boys. They aim to put knowledge into his head, to train him and discipline him. He can always take it with him. The Soviets have merely taken over and applied on a mass scale what many groups, including the top professional groups in Holland, France, Denmark, Germany, have thoroughly understood for generations or even for centuries or millenniums.

I have a suggestion to you this morning, at the bottom of page 9 of my testimony, on how you can begin to convey some sense of the urgency of this new problem, at least to your colleagues here on the Hill. You aren't likely to do this with statistics. The lack of publicity for the DeWitt report is perhaps a good illustration of that. Even though I had spent weeks preparing for my trip of last fall to the U. S. S. R., including 2 weeks in London, I was emotionally aroused myself only by my firsthand exposure to what is going on.

I think the third paragraph of page 10 also confirms what I have just said.

One sees youngsters in their mid-teens, and young Russian married couples, in the bookstores browsing at the sections featuring scientific works. They buy books on nuclear physics in preference to novels or handbooks on interior decoration. This is how to get ahead in Soviet society today.

This is terrifying to me, much more terrifying than the fact that the Soviet steel production is going up, which is terrifying enough, because the Soviets put their steel production not into Cadillacs, refrigerators, and gadgets, but they put it into armaments and heavy industry and war potential.

In Moscow I spent several hours with the pro-rector of the University of Moscow, Professor Vovchenko. The university, which enrolls 23,000 students, dominates the city. Wherever you look in Moscow it is more conspicuous than the Empire State Building in mid-town New York. The recent investment of 3 billion rubles for this new building is astonishing by our standards. It is equivalent to at least $150 million, figuring the ruble at its minimum of 5 cents. I am a trustee of the University of Chicago, and I would say roughly $150 million is what has been put into that plant since it was started by Mr. Rockefeller in 1891. It must be one of the most costly plants in our American university work. In Moscow the Communists put a minimum of $150 million into one building.

If the ruble is worth more like 10 cents than a nickel, as many contend, that would make $300 million in this one building. It con-

tains 1,900 laboratories. In it work 2,000 teaching professors, with original research also compulsory, and 500 professors who are full time on research. There is no permanent tenure. If these professors don't deliver in scientific research they are fired. It is just as fast and simple as that.

Representative PRICE. You saw this, Senator. It isn't guesswork. You actually made a tour through these facilities.

Mr. BENTON. I visited and looked at this building and talked to the pro-rector in his office there. Twice I walked around it and looked up at it. I looked at the students. I walked through the hallways. But when the pro-rector tells me there are 1,900 laboratories, I believe his statistics but I have no way of checking them. On that kind of statistic Professor DeWitt and other observers find the Russians pretty accurate. But what have we of the United States got to lose if we accept it? We can see their jet bombers and their jet planes. We know they are exploding atom and hydrogen bombs. A country can't do these things without top-trained scientists. This is testimony that we all must accept.

Representative PRICE. Were you in close contact with some of these educator scientists?

Mr. BENTON. I talked to the pro-rectors at 2 of the 3 leading universities. I spent 2 hours with the Minister of Higher Education, who is a metallurgist, and more than 2 hours with the Minister of Education who has all the 10-year schools under him. These men and others in key roles made a profound impression on me as able, dedicated and tough men. Sometimes I felt strongly that they were ignorant men, which is most terrifying.

Many an American businessman concluded that the most terrifying and dangerous competition is that which is rich, strong, and ignorant. This is our part of our American dilemma and problem as we look at these younger operating men who now have control of these vast operations in Russia today. Senator Anderson may have heard me quote Lenin before to the effect that when he came into power he said, "We must be prepared to sacrifice two whole generations."

These men in the key operating roles in the U. S. S. R. today are the third generation. They have never been exposed to anything but the Communist, what they call the Marxist-Leninist line. This makes them very one-sided. I believe they are thoroughly indoctrinated. They would talk to me in Marxist terms as if, of course, any intelligent man would agree with their Marxist interpretations of history. That is the only interpretation they have ever seen or read or heard.

I urge you to read the section in my prepared testimony starting on page 11 about the visit to the tekhnikum. I will read just the middle paragraph.

In Kiev I visited a tekhnikum. We have nothing like this in the United States. Dr. DeWitt estimates there are some 3,700 tekhnikums in the U. S. S. R. They are a unique Soviet institution, a kind of vocational college producing "middle-trained" specialists. These tekhnikums are all run by the ministries. I had never heard of them until I went to Russia. I didn't know they existed. A tekhnikum maintained by the ministry of health will produce "feldshers," graduates about halfway between the level of a nurse and a doctor. Such an idea had never crossed my mind. I imagine 90 percent of the

work of most doctors is work that could be done by a feldsher, a trained man who is halfway between nurse and doctor.

The tekhnikums give 4-year courses to those who have finished 7 primary grades. They give 2- or 2½-year courses for those who have completed the 10-year school. Of course by 1960 all tekhnikums will require a 10-year school degree.

The Ministry of Agriculture, Senator Anderson, will have the big agricultural tekhnikums, for example, training people to be the heads of the collective farms. There were 30,000 new heads of collective farms installed this year, I was told on my visit, and this entailed a vast turnover. I give this as an illustration of the Soviet's constant drive to improve their technical leadership. They even have tekhnikums in music and in art.

Some of these students are not necessarily inferior to the cream of the graduates of the 10-year schools who go on to the universities and the higher institutes. Some just don't want to spend the 5 years in the university, let us say. Maybe the boy wanted to get married, and all he was willing to take was 2½ years. Again, when the students finish the tekhnikum, they are again creamed off and the top 5 percent is automatically pulled out of the tekhnikums into the universities or higher institutes.

Of course there is no problem of financing talented students in Russia because they are on scholarships and have been funneled into the lines where the government wants them by what the Soviet propagandists call the "process of persuasion," which means big scholarships in aeronautical engineering, let us say, and no scholarships in history, just to give an example.

Starting with next fall, as announced at the 20th Congress last February, there will be no fees of any kind for any student at any level in any institution in the U. S. S. R. Everything will be free.

I hope you will read the next few pages of my prepared testimony, Mr. Chairman. I think you and your committee will find it interesting. Life Magazine found some of the material I developed on my trip to the U. S. S. R. sufficiently interesting to use it as captions on a lead story dealing with Soviet science, or at least I thought they did. I tell you this to show you that in my humble way I am doing what I can to publicize this grave problem which came so forcibly to my attention on my recent trip to Russia.

The coal and coke industry have 50-odd tekhnikums. There are 2,500 students in the one I visited in Kiev being trained how to make coal mines, builds roads in coal mines, build the buildings for coal mines, and put the electric and telephone communications in the coal mines.

Think of the volume of this training, Mr. Chairman. Think of the 3,700 tekhnikums and the 2½ million students. These are all in addition to the 1,825,000 Soviet students in the universities and the higher institutes. To describe this we have no parallel whatsoever. We don't have the words in our vocabulary to describe to the people of the United States what a tekhnikum is and the significance of 3,700 teknikums to the Soviet economy and political threat.

One reason I think the Soviet economy is going to drive ahead is this enormous stream of highly trained manpower being poured into it: A nation can't turn out 4 million specialists between now and

1960 and pour them into its economy without their having a stimulating effect on that economy. Senator Anderson as a businessman will understand why I was impressed—and your committee won't get such an interpretation from the reports of its experts and statisticians—by the fact that the Soviet bureaucrats are beginning to decentralize. They aren't afraid and scared as they used to be. Khrushchev and Bulganin would not be leaving the country as they are if they were afraid that they would be destroyed while their backs were turned as Stalin used to fear destruction through the stab in the back. With more confidence, Soviet leaders are encouraging decentralization. General Motors taught American industry in the 1930's the enormous values of decentralization applied to American productivity.

So though the goals that the Soviet leaders prophesy, a 65 percent stepup in heavy goods and a 70 percent stepup from present levels by 1960 sound almost fantastic to us, we must remind ourselves that they have not only made past goals, they have not only lived up to most of these alleged visions of Stalin—but they have often exceeded them in the face of the scoffing of our economists both here and in London. In the interest of our national security I believe we would now do well to listen to the Russians and, at least until we know something otherwise, to believe what they say and to act accordingly in our own self-interest.

Chairman ANDERSON. I was very much interested in what you had to say about the fact that Khrushchev and Bulganin are not frightened to be out around the world. There was a story of the Teheran conference which I know was correct, that Stalin insisted on having a room right across from the conference room, but nobody ever saw him go from one room to the other. When the doors opened in the conference room there was a milling of tall Cossack guards like a football team huddling and that circle kept sort of circling and circling and Stalin was inside it somewhere, but he never allowed anybody to see him.

I remember very well my friend who had charge of things in Moscow telling me once if Stalin was to go to the railroad station, all day long from 5 o'clock in the morning until 10 o'clock at night there was a steady parade of black limousines and nobody ever knew in which limousine he went because there was always a steady stream. He wouldn't take any chance.

That is only a few years back. This particular man was there in 1946. This is 10 years ago now.

Did you find that Khrushchev and Bulganin dared to walk around the streets of the city?

Mr. BENTON. I don't know about that, Mr. Chairman.

Chairman ANDERSON. They certainly are not afraid to come to other countries.

Mr. BENTON. If I had not met Mr. Bulganin at a big reception for Premier U Nu, I don't believe all these appointments would have been arranged for me. At these receptions the Soviet leaders act as if they are fully relaxed and confident. Bulganin strolls around those big parties, just like a United States Senator campaigning for office.

I assume you know, Senator, that most of the Western diplomats in Moscow are persuaded that Stalin was assisted to his death. Whether

true or not, I can't say, but even the belief is of interest. You may not have heard the story about the member of the Presidium in charge of Soviet planning in 1949 or thereabout, the development of the 5-year plans, whose name I think was Voznesensky, one of the top nine men in Russia at that time, who went wrong on Stalinist ideology in his economic plans but, who is now rehabilitated and praised for his leadership and courage. He was to be exiled to Siberia, to some remote post. The paper of exile came to Stalin, so the story goes, and across the paper Stalin wrote "death by execution." Every member of the Presidium then clearly knew that it could happen to him, too. If it could happen to Voznesensky, it could happen to him. So each lived in terror.

Stalin certainly was no fool. He must have recognized the danger in which he walked. He surrounded himself with armed guards and secret police.

When we saw the pictures of Khrushchev and Bulganin riding around in open cars in India with milling crowds around them, we knew that to some extent at least the psychology had changed, and so, too, in their recent rip to England. The fact that they leave home at all, as they do, is also significant, I think.

At any rate the Soviets are decentralizing and the fact that they are decentralizing, giving much more power to local people, wider establishing areas of authority, in my judgment from my experience in America promises increased productivity for the U. S. S. R.

Representative PRICE. While we are talking about the changes going on in Russia, the mere production of the scientists and highly trained people, with independent minds and thinking, I think Secretary Dulles or maybe it was Allen Dulles suggested that possibly this might be the Achilles' heel of the Communist system. Do you think there is any prospect that that could happen, that it might break down the present communistic system?

Mr. BENTON. I touch on that in this paper I've prepared. I have great respect for Mr. Allen Dulles. I came down and visited with him before I went to Russia. On my trip I looked for supporting evidence for what he calls cautious hope, but I couldn't find any anywhere. I just could not find it applied to these Soviet scientists, technicians, and engineers. This of coures doesn't mean it doesn't exist, my visit was short, but its my opinion that the Communists may have found a new formula through which they develop great scientific skill and freedom in scientific research and at the same time complete docility in the scientists on economic and political matters. The Communist leaders are not primarily interested in the ideology of these scientists and technologists. They just want them to deliver. Perhaps they have something of the attitude toward them that we have toward our admirals and generals. Your committee doesn't sit here wondering what our admirals and generals are thinking about from the standpoint of political orientation. Primarily, you want them to deliver. In the U. S. S. R., when the scientists deliver the Communist leaders pin the Star of Lenin on them. I must say from my own experience even here in the United States, with our admirals and generals, I think it is possible to train top scientists and technicians who are, let us say, docile politically or indifferent politically. This is what I believe the Soviet leaders have learned how to do on a

much intensified scale. Those Soviet leaders that I met, far from giving me any evidence that they were thinking for themselves and thus about to abandon Marxism and embrace democracy, gave me every impression of being deeply dedicated Marxist-Communist leaders, prepared to make sacrifices and to run risks for the promotion of Marxism. I hope Allen Dulles is right. I was there only for a month. I can't speak Russian.

How do I know but that at every interview a sound recorder was hidden behind the picture? Every man I talked to may have figured what he said to me was being inspected by the members of the secret police. One deals with a lot of inponderables when you are in Russia. But I believe Allen Dulles doesn't have too much evidence to back up his hope.

I am now going to the proposal in the middle of page 14.

I urge the membership of this subcommittee to go to the Soviet Union and see for yourselves. With all the studying I did before I went to the U. S. S. R., I didn't see, until I had been there this issue we are discussing today, or feel it emotionally. Let your committee apply for visas which put to the test the spirit of Geneva, this new Soviet propaganda slogan which was being hammered in all media when I was in Russia. Apply for the visas now so that you will be sure to have them by the time Congress is ready to adjourn. If Senator Anderson would go over and look at this, I can tell you that his emotions would embrace what he now sees intellectually, and he could speak with a great deal more power when he came back.

Chairman ANDERSON. I want to say right there, Mr. Benton, that we took 12 members of the Joint Committee on Atomic Energy to the Atoms for Peace Conference in Geneva. I have refrained from what we call junketing. I think that was my first trip anywhere as a Member of Congress. I did make some trips in the Cabinet, but that was required. It seems to me that the centire program of legislation, compacts, and agreements, was simplified by the fact that Senator Pastore and Senator Bricker, for example, who are the two top members of our committee dealing with these international agreements, were there and met a great many people and obtained ideas that were very useful. I am sure that whatever was spent in going to Geneva was a very minor amount in comparison with the results obtained.

Mr. BENTON. I am sure of that.

Chairman ANDERSON. I don't want to go into details. We saved the country a great many millions of dollars by finding some money that was being foolishly spent. But I am interested in this suggestion because I had been told that it might be possible to do something of this order. I noticed the other day that 20 or more American scientists within the last 2 or 3 weeks got an invitation to visit Russia, and many of them are going, just as the Russian physicists came to the Rochester Conference on High Energy Nuclear Physics the other day and made a very fine contribution. I am very much interested in what you have to say here. I think this a very good time to say it.

Mr. BENTON. Mr. Chairman, even if you had only one day in Russia, you could go through one tekhnikum and I tell you this would have deep effect on you and any who shared the experience with you. I agree emphatically with Senator Anderson. When I was serving as

Assistant Secretary of State I spent much of my time going from office to office up here on the Hill trying to persuade Members of Congress to go overseas and to expose themselves to the problems facing our country in the field of propaganda, information, and cultural exchanges. I believe the Smith-Mundt Act resulted largely from the personal observations of Members of Congress who, going outside this country, saw what we were up against in a way that can not be seen sitting here in Washington. These trips abroad are not junkets. Ten or 12 years ago the voters and taxpayers more or less thought they were, but the postwar success of such trips in many fields, including even housing, I think has killed that word "junket" and it is out of the public mind today. I believe this trip by your committee would be applauded by the press and by the educational groups of the country.

Representative PRICE. Senator, when you were over there did you have the feeling that they were dealing frankly with you and letting you see the things that you wanted to see, or did you have the feeling that they might be holding back?

Mr. BENTON. Mr. Chairman, it depends on the level on which you are seeking information. Before I met Premier Bulganin I felt frustrated and was so annoyed with In-Tourist, the Soviet agency handling my trip, that I was thinking of getting on a plane and coming home. I had been in the U. S. S. R. several days. Not an appointment had been made. I went to Kiev in my disgust and distress, on In-Tourist's assurance that they would have appointments when I returned. When I got back, no appointments. Then I met Premier Bulganin at a reception for U Nu, and he said to me, "You will have the cooperation of the government," and from that time on I saw 40 to 50 of the top leaders, many of whom had never been talked to before by a western representative in Moscow. Thus, many people go to Russia, including colleagues of Senator Anderson, who want to see Khrushchev, Bulganin, and other members of the Presidium and who fail to see them. I didn't go there to see these top political leaders and didn't even try, although I met them at receptions. I wanted to see the man in charge of radio and television, the man in charge of the school system, the man in charge of book publishing, the editor of the great Soviet encyclopedia, and others. Our Embassy in Moscow told me these men had never been talked to before. As they put it, they were just names. My impression was that these men treated me with considerable candor and forthrightness. My impression also was that they are remarkably well-trained and able men. They have come up—Senator Anderson with his background will understand what I mean by this—through about as ruthlessly competitive a system as a man can come up against. These are the fellows who have risen to the top, the sons of peasants, coal miners, railroad workmen, right out of the guts of the people.

When I asked Pervukhin, the head of the great electrical ministry, about his background and congratulated him on his youthful look—he is 53 years old and looks about 40—he drew himself up and said, "I am the son of a blacksmith and my father made me well."

I give that as an illustration only to give you the emotional power of these men of high ability whose ignorance of the West is one of the terrifying facets that one runs into when he visits Russia.

I suggest to your committee that, like me, you do not seek out the political leaders, but visit the ministries of education and higher education, the ministry of culture, the top newspapermen, and so forth. I would urge, out of my experience, upon a congressional group going to Russia more or less to abandon the politicians because I don't think you would learn too much talking to the members of the Presidium, though as a matter of courtesy I would agree a group of Congressmen perhaps should call on them. But go to the universities and the tekhnikums. Look at some of those laboratories in the University of Moscow. Ask to talk to some of the professors.

Senator Anderson, you may remember the time, when you were Secretary of Agriculture, back 10 years ago, when I was told that my efforts blazed the path for the subsequent widespread practice by committees of the House and Senate to make study trips abroad. With the aid of a few friendly editorial writers, I helped kill the journalistic idea that such trips were junkets.

Paul Hoffman once went so far with me, Senator Anderson, as to say that he thought that this extensive traveling abroad, which was stimulated at least in part by me at that time while I served in the State Department, laid the basis for the Marshall plan. If a couple of hundred of our Congressmen hadn't been overseas and hadn't seen some of the problems first hand, and had not had the time to think about them because they were together overseas instead of answering the telephone and running for roll calls, the climate would not have been developed in which the Marshall plan was put through. I don't say that is true, and Mr. Hoffman would not say it is true, but if it might be true—then that is a very big dividend for such trips overseas by committees of Congress, because the Marshall plan is one of our most constructive and important post-war pieces of legislation.

At the bottom of page 15 of my testimony (reading): We cannot duplicate in this country the full array of pressures and incentives the Soviet Union is able to bring to bear on its young people, and we wouldn't want to duplicate it if we could. Theirs is a highly centralized, pushbutton system. The curriculum is standardized right up through to what we call the graduate school level, with only one basic choice open to the students, the seeming choice of a career which he makes at the end of the 10-year school.

Let us skip to the bottom of the next page, Mr. Chairman. Here I give on page 16 the rewards of a typical professor. Just a typical professor gets 6,000 rubles a month, 10 times the average workman's pay, and some professors get up to 40,000 rubles a month. Further, the top income tax is something like 8 or 10 percent, and the top inheritance tax is something like 8 to 12 percent.

This is the new plutocracy, the scholars and professors and scientists of the U. S. S. R.

On page 17, Mr. Chairman, at the top of the page. Indeed, why shouldn't a young engineer prefer to build his career in Bridgeport or Topeka rather than Kabul or Jakarta? If your son were an engineer and he were choosing between Pratt & Whitney in Connecticut or the Irrawaddy River of Burma, which choice would you advise if you wanted him healthy and wealthy?

I suggested one answer to this national problem at the memorial luncheon this year for former Secretary of War Patterson. That is

the creation of the United States Government of "Technical Assistance Academies," comparable to the United States Military, Naval, and Air Force Academies, but designed to produce foreign-aid specialists. In the Journal of the Foreign Service Association I read recently of a proposal for a career service in technical assistance. Of this I am doubtful, but my proposed academies should require 3 years' service overseas from the graduates, in return for their free education, and from such beginnings I agree that a career service could develop. These technical academies should be operated in conjunction with existing high-level institutions such as MIT or Cal. Tech. The entire student body should be fully supported while in school and be given a special status under the draft such as Reserve commissions on graduation.

Mr. Chairman, I think it is just as urgent and just as necessary for us today to train people technically to serve overseas for the United States as it is to train Army officers. The origin of West Point, you may recall, was in part because we didn't have any engineering schools in this country and we had to start a college to train engineers for the West, to go out and make the surveys and to open up the West for the people of the United States. We face that same kind of need today applied to overseas.

I may say that I think our whole draft structure applied to the training of scientists should be reexamined. You would not catch the Russians—though I don't like to cite them as my authority on this, not by any means, but with the need we have for physics teachers in the high schools, training only 125 last year—you wouldn't catch them taking physics majors out of colleges and tossing them into the Army for a couple of years when they are so urgently needed in our educational system.

My suggested "West Points of Point Four" should teach not only engineering and technical subjects; they should also include emphasis on the recognition of human values, including the use of educational techniques, and insist on a thorough grounding in the liberal arts. I toss that in to show that I am not talking about imitating the Russian techniques or methods of training, but the training of engineers and scientists in our own tradition of the liberal arts.

What we require today, and at once, as Chairman Price says, is a "crash program." How can this be launched, and at once? It seems to me that the beginning of such a program must consist of Federal scholarships on a dramatic scale.

This is my third specific proposal, and on my specific proposals Senator Anderson has asked me to pause.

Last month in Chicago I proposed a national competitive scholarship program beginning with 20,000 scholarships a year, each covering 4 years of college. I further proposed that this number should be increased as rapidly as the administration of the program and the absorptive capacity of the colleges and universities permit, to a level of 100,000 scholarships a year. Trained manpower is like money in the bank for the United States. It is our most important national resource.

Premier Bulganin referred to Soviet trained manpower as "our (Soviet) gold reserve." This was in his speech at the 20th Century Congress.

I wonder if members of the committee know that of the 20 percent top graduates of our high schools, only one-quarter finish college. Yes, if you cream off the top 20 percent of all high-school graduates, only one-quarter finish college. Further, for every student we have in college today there is at least one of comparable and equal ability who never gets to college. This situation isn't due wholly to economic deficiencies in the background of the students, but a big part of it is, a half of it or more. There are estimates that each year as high as 150 to 200 thousand highly qualified high-school graduates never get to college because they can't swing it economically.

When I later mention scholarship priorities for scientists and engineers I don't for a moment mean to suggest that more scientists and more engineers will solve our problems. For our national defense and our national well-being, we need better educated citizens in many fields. We are facing, of course, a big shortage of doctors, and shortages are looming ahead of us in many fields.

The final paragraph on page 20, Mr. Chairman: I have a further immediate suggestion. I heard recently that only 125 new teachers of physics were available last year. The reasons are several, but I believe a partial cure could be achieved by paying higher salaries to high school teachers of physics and mathematics and all the natural sciences. If mathematics and the sciences are harder to learn and harder to teach, why shouldn't the teachers in these fields get higher salaries? And should they not be able to apply for exemption or deferment by Selective Service? If a young man is more likely to secure exemption or deferment as a physics teacher than as an English teacher, or than as an employee of General Electric, will we not secure more high-school physics teachers?

My comment here is subject to the same qualification and examination which I made earlier about scholarships. We must come in the long run to Federal assistance of teachers in many fields.

Another grave problem is the control exercised by teachers' colleges. An honors graduate in physics from Yale cannot teach physics in the public schools of my home State of Connecticut until he has earned a certificate from a teachers' college. Neither can a Princeton physics cum laude teach in New Jersey.

Let me conclude with this thought: Education is one area where we in America have nothing to lose if we accept Soviet claims and the Soviet challenge. Intercontinental competition in education need be no challenge to an arms race or a war. If the Russians goad us to do a better educational job ourselves, then we shall only do what our own best tradition calls for—what we should be doing even if the Soviet Union were to sink suddenly into the sea. But if we are complacement about our educational efforts and system, if we allow ourselves to fall behind the Russians, we may find ourselves outwitted, outmaneuvered, outthought, and outbuilt throughout the world.

Do you recall the comment of the Toynbee, who has said that maybe communism will turn out at the end to have been a good thing for the world because it will force us of the west to examine a lot of our tactics and policies and will force us to do out of fear some of the things that we ought to be doing and should be doing even if we had never heard of communism? One of these is greatly to improve the educational opportunities for the youth of the United States.

I thank you, Mr. Chairman.

Representative PRICE. Any questions, Mr. Cole?

Representative COLE. Having come in so recently and not having the full benefit of your full statement——

Mr. BENTON. I am very pleased that you came.

Representative COLE. I was struck by your personal observations in Russia and the suggestion that it might be worthwhile for the Joint Committee to visit Russia. I don't know to what extent you discussed your Russian visits in your statement. If I do ask a question which calls for an answer which is repetitious, please remind me of it.

How long were you in Russia and how recently?

Mr. BENTON. Last November. I was there about 3 weeks and then I spent a week in the satellites.

Representative COLE. What part of Russia did you visit?

Mr. BENTON. Leningrad, Moscow, and Kiev. I had a much longer trip planned, Mr. Congressman, twice as long a trip. I was going out into Asiatic Russia, but my wife broke her leg, which delayed our departure, and we had to compress our projected trip into a month. But this unhappy accident had its fortuitous side, it did give me a chance to prepare for the trip far better than otherwise. In total, including the unexpected 3 or 4 weeks, I spent perhaps as much as 6 or 8 weeks, including 2 weeks in London with officers of the British Foreign Office and other Russian experts, preparing for the trip. Thus I would not want you to judge the trip only by 1 month. Incidentally, your committee can learn lots of things about the U. S. S. R. much better in London or in Boston than you can in Russia.

Representative COLE. Or even in Washington.

Mr. BENTON. Much better than in Washington. I mean you can learn much more about the U. S. S. R. before you get there, if you go to the right people, than you can possibly find out after you leave the plane in Leningrad. The real combination is preparation before you go, ideally, and then a reasonably leisurely visit. I am sure if your committee took such a trip, a point which has not been brought out, your committee ought to spend 2 or 3 days in concentration preparation with some of the able people in Washington and, indeed, you should bring down to join them the Soviet experts from New York and Boston and other places.

Representative COLE. Was your tour in Russia circumscribed in any respect or to what extent was it circumscribed?

Mr. BENTON. No, not at all.

Representative COLE. You mean you were allowed——

Mr. BENTON. They gave me permission to go anywhere.

Representative COLE. You could go any place you wanted?

Mr. BENTON. But I didn't ask to go to many places, or want to, or have the time to, so I didn't put your question to a real test.

Representative COLE. You could have gotten into an automobile and driven any place throughout the country?

Mr. BENTON. The In-Tourist Bureau always had a man with me.

Representative COLE. I know. I think any of us would want a guide, a mentor alongside.

Mr. BENTON. I took along with me from here, a crack man of my own, which, of course, I would advise your committee also to do. Thus I didn't need the Soviet In-Tourist man. In a couple of interviews I managed to shake him. He then made it very clear that everybody

that I talked to wanted him to be there, too. So he was always with me. He was a representative of the In-Tourist Agency which handles tours. Senator Malone knows him well, so he says.

Representative COLE. Then there was no limitation or restriction whatever on your travel, either by motor or by train? I don't know whether you tried to travel by train or air.

Mr. BENTON. We used the airplanes, Mr. Congressman, and Ambassador Bohlen laughingly said that he had more confidence in the Russian airplanes than in the American airlines. I tell you this to reassure you about your committee's safety if you follow my recommendation. The Soviet planes give you the impression of very great efficiency. We traveled on Bulgarian planes, Polish planes, Czech planes, Russian planes, Finnish planes. They all give you the impression of efficiency.

Representative COLE. Within Russia itself there was no restriction on travel?

Mr. BENTON. Not at all, but I did not put this to any service test.

Representative COLE. How about places that you might want to visit, institutions? Could you go any place you wanted?

Mr. BENTON. The only two institutions, if they could be called institutions, that were closed to me—I was eager to try to get to Cardinal Mindzenty and Cardinal Vishinski in Budapest and Warsaw.

Representative COLE. Cardinal Vishinski?

Mr. BENTON. Yes; he is the Polish cardinal. He was the head of the Polish Catholic Church. The name is pronounced Vishinsky as we know it from the Russians, but it is spelled differently, the Polish spelling and the original spelling. The Vishinsky you know is a Russian branch of the Polish family, but spells his name with a "y" instead of the "i", and with a "V" instead of a "W." Apart from these refusals appointments were made for me to see those I wanted to see, with one further exception in Moscow, but these appointments resulted, I believe, from the good luck of my meeting with Premier Bulganin at a reception for U. N. Even for a congressional committee, I think every effort should be made to arrange them far in advance.

There was one member and only one member of the Presidium I wanted to talk to, but I never could see him and this in spite of urgent appeals, including a within appeal to Premier Bulganin himself. This was the member of the Presidium who is believed to be in charge of Agitprop, the central mechanism of the party through which the press and radio are controlled, movies are controlled, and the propaganda line is laid down.

Representative COLE. What do you think the committee might learn by a first-hand visit apropos of the Russian system of training engineers which the committee could not learn by sitting down and visiting with the people in Washington or Boston?

Mr. BENTON. That is a key question, Mr. Cole. I think the first answer is that you are not going to sit down in Washington. You won't and can't take the time and put in the effort here.

Representative COLE. You are right there.

Mr. BENTON. You are not going to sit down with the right people. This makes the question a little bit theoretical. Even if you got everything by sitting down with the people here, you still have two advan-

tages by going. You get the answers to your questions emotionally and with the power of one who has seen for himself. I spent at least 6 weeks preparing for my trip, including 2 weeks in London which is more than any congressional group could conceivably put into it. When I left for the U. S. S. R., I didn't even begin to have the comprehension or strong emotional reaction to what I regard as the grave dangers to the safety of the United States growing out of present Soviet educational and training techniques, I didn't even recognize these until I got there and was personally exposed to them.

A second great advantage you have if you go, even if you know everything before going, and thus perhaps my presence here this morning shows, is that your committee will come back and speak with authority and power because you have been there and your colleagues will listen to you and believe you, otherwise if you say "I got this from a guy in the CIA and a Harvard professor." Thus, with this you are not going to service a respectful audience. You have at least these two advantages by taking the trip even if you were able to put the same time into the problem and could get everything here that you get there, which I suggest is manifestly impossible.

Representative COLE. Did your observations on the spot or on the ground confirm the information that had been reported to you from these various sources in Boston and New York?

Mr. BENTON. Yes. Further, I got much information I did not get before I went, but the information before I went was confirmed by and large as being accurate. But we don't have enough information here about the U. S. S. R. Part of our problem is the difference between the expert and the policymaker. I go back here to what Al Smith said, that experts should be on tap and not on top. You legislators must listen to the experts, but you men in Congress must then have the breadth of experience to make the hazardous guesses about the future and the riskier decisions of what do do about it. So in the U. S. S. R. I confirmed what I had, but I got much, much more that I don't think you can get from the experts because they don't see it the way a congressional committee would see the same questions if it went over there.

What would you do? I think if you had only 1 day there and could go through the University of Moscow and one of these tekhnikums, as I did, it would make an enormous impression on you. I don't believe there is one of you who wouldn't make a speech about such a day when you got back, and command the headlines.

Representative COLE. I am sure, even though we spent only 1 day, we could come back and make a speech about it.

Mr. BENTON. And good campaign speeches, too. One of the real questions I asked in my prepared testimony which you missed was, What is the reason for the public ignorance and public apathy? One of the strong reasons for this trip I recommend is that it would help dispel the apathy and cut through the ignorance, because I think every one of you who went would do writing and speaking when you got back, and that is one way we educate the American people through our political process.

Representative COLE. Now to your suggestion about the scholarships as a device by which we might increase our available supply of engineers, what information or evidence is there, if any, which might support the statement that the reason why more young Americans do

not go into engineering is because of the economics, the cost of it? I have not observed and have not been told or seen any indication that the reason why young Americans don't become engineers is because they can't afford the college education and training which is necessary. Is there sufficient evidence?

Mr. BENTON. Yes; there is. Studies have been made on that by distinguished educators at Columbia and elsewhere.

Representative COLE. Is the economic factor more persuasive in deterring boys and girls from going into engineering than into any other type of college training?

Mr. BENTON. I don't know the answer to that specifically, Mr. Congressman. The studies I have seen apply to going into college, in general, by the smarter high-school boys and girls.

Representative COLE. That is true overall.

Mr. BENTON. Yes; they are authoritative studies. I saw one giving figures of 160,000 talented, top high-school graduates who do not go to college each year for economic reasons.

Representative COLE. There is no question that a great many of them do not.

Mr. BENTON. The information you seek applied to engineering candidates. It may be available and it may not. I don't know.

Representative COLE. It has never been brought to your attention that economics was a deterrent?

Mr. BENTON. Specifically on engineering?

Representative COLE. Yes.

Mr. BENTON. I would conclude, wouldn't you——

Representative COLE. Any more so than any other.

Mr. BENTON. I have no figures which indicate any more so or less so than any other. Indeed, it is encouraging that enrollment in engineering schools have gone up in the last year or two. A few years back there was a far smaller enrollment. I thought I had figures here and I do have them somewhere. I can't put my hands on them. I will furnish them for the record.

Representative COLE. Has a survey been made to show the capacity of engineering schools?

Mr. BENTON. I presume so, but you are over my head here. I am no expert on this. But I have read a good deal about it.

Representative COLE. I wonder whether our engineering schools now have the capacity to accept double their present enrollment, let us say.

Representative PRICE. We had testimony before the committee that they are not in that position. One of the problems we are facing is the inadequacy of facilities.

Representative COLE. Engineering schools are now filled to capacity?

Representative PRICE. Most of them are.

Mr. BENTON. Not too long ago they were not. Whether they are now I do not know. But you know that the predictions of the forecasters in educational trends, Mr. Cole, are that our college enrollment will double by 1970.

Representative COLE. I wasn't aware of that.

Mr. BENTON. The United States doesn't have facilities anywhere for this oncoming flood. This includes medical schools, engineering

schools, all our technical schools, and indeed all our colleges and universities.

Representative COLE. If it is true that the engineering schools are now filled, then providing scholarships as an inducement to individuals to go into engineering would not necessarily accomplish what we seek.

Mr. BENTON. The universities and colleges—I am a trustee of a college and also of a university—get their money in several ways. One of the major sources of their money of course is tuition. If they don't have to give scholarships, and if the talented boys are provided with the scholarships by somebody else, and the money therefore goes to the university or college, this money underwrites them in part at least in the expansion of their facilities. If we knew in the college of which I am a trustee that we were going to have 500 more students in 5 years paying full tuition, this could embolden the trustees to move ahead with expanded facilities to a far greater extent than we now feel warranted.

I am not saying, however, that the scholarship itself would be sufficient to underwrite the expansion. By and large, universities make money on their undergraduates, which then is spent on the very heavy losses they incur on the graduate training.

Representative PRICE. We had testimony about the schools being pretty well filled up, but I don't mean they are at capacity or over their capacity. Some of the colleges were concerned that about 50 percent of the freshman classes were failing and were dropping out of school.

Mr. BENTON. The record at our great State universities used to be—I know it was true at Illinois when I was an officer of the University of Chicago and was interested in it—that half of those who entered freshman year didn't finish freshman year, but this was because under Illinois State law—this particular point I know was Illinois law but it may be true in every State—the University of Illinois had to accept every student who had graduated from any Illinois high school. I certainly would not propose a national scholarship program except on a competitive basis for the more talented boys and girls. These are the ones we should be looking for and to whom we shall extend the helping hand.

Here are the figures, Mr. Cole, if I may give them to you. These are the ones you asked for earlier, which I couldn't remember. I read them in testimony of Harry Kelly before your committee, assistant director for scientific personnel and education of the National Science Foundation.

Engineering school enrollments are on the increase both as to absolute numbers and as a proportion of all college enrollments. From the low point in recent years of about 34,000 entering engineering schools for the first time in the fall of 1950—

these are the low point of people getting out last year and the year before—

engineering schools reported an entering freshman class of 72,800 in 1953.

That is more than double.

First time enrollments in engineering as a percentage of all first time enrollments have gone from 6.6 percent in 1950 to 10.6 percent in the fall of 1955.

It may be the mad scramble of these big corporations for engineers, Mr. Cole, which helps to account for this. You may have seen front page stories of this competition. The corporations are offering bonuses, vacations, and all kinds of privileges to boys who are not even out of college yet, if they have engineering training.

Representative COLE. Reverting to the school system in Illinois, do you recall what percentage of the high-school graduates in Illinois went on to college?

Mr. BENTON. Roughly 30 percent I think. I don't recall the figure exactly. I do recall that some years back, of those who entered the freshman class at the University of Illinois, only 50 percent got through their first year. I can also give you this figure: Of the age group eligible for college and universities of the United States today, about 30 percent are enrolled.

Representative COLE. I had in mind particularly to find out the percentage of graduates in a locality which provided free college education. How many of them went on to get that college education which was free to them?

Mr. BENTON. I don't know. One of the great needs of the United States, in my judgment—and former President Conant, of Harvard, advocates this—is an enormous expansion of our junior college system so colleges will be available to students living at home. You may be surprised, as I was, when I learned 6 weeks ago that 50 percent of all the junior colleges of the United States are in the State of California. I thought this amazing, and an amazing indictment of many other States. I asked an audience of educators what kind of situation is this, that the United States finds 50 percent of all junior colleges in one State? As you probably know, California sends agents as far afield I think as Illinois recruiting teachers. They say, "Come on out to California, and we will give you a much better climate as well as a better job."

They even take the teachers to California from institutions like the Peabody Institute, founded to train teachers for the South.

Representative COLE. The agents go farther east than Illinois?

Mr. BENTON. They do.

Representative COLE. From what I have observed and have been told That is all I have.

Representative PRICE. Thank you very much, Senator.

The committee certainly appreciates your testimony.

Mr. BENTON. I am pleased that Mr. Cole came in. His questions have helped clarify some of these points greatly, particularly on the projected trip of your committee which I urge for your consideration.

Representative COLE. I don't know that Mr. Price, the chairman, has indicated to you the fact that the committee has for some time considered the advisability of visiting Russia——

Mr. BENTON. No; I did not know that.

Representative COLE. Particularly from the atomic aspect of the committee's responsibility. Of course, the committee is likewise not only interested in the question of shortage of scientific manpower, but I don't know of any committee in Congress that has a more direct responsibility to find some solution to meet that shortage than the Atomic Committee.

Mr. BENTON. I concur in that, Mr. Cole. I opened my testimony bewailing the fact that these urgent and important hearings of this committee are not getting widespread publicity. I think these are as important hearings as are now going on in Washington. Much more important than the farm hearings and a lot of others that are occupying the headlines. They are not being called to the attention of the people of the United States. The people are not aroused about them and about what is happening to our own educational system. One way to arouse them most certainly is to point out to them the accelerated progress of the Russians. I like a quote from the French philosopher, Leon Bloy, who spoke of the "Good news of damnation," by which he meant that the fear of hellfire often keeps us performing satisfactorily and makes us do those Christian acts which we would be well advised to do anyway. I think we are in somewhat that position applied to our own American educational system.

I thank you, Mr. Chairman, for your courtesy and kindness.

Representative PRICE. We thank you for your fine statement and we also appreciate the fact that you traveled many hundreds of miles just to make this appearance here this morning and took time out, I understand, from your vacation period to be here. We are most grateful to you.

Mr. BENTON. Mr. Chairman, it is a pleasure. It is the writing of the statement that is the hard labor.

Representative PRICE. Thank you very much, Senator.

Mr. Haldane, would you identify yourself for the record, please.

STATEMENT OF BERNARD HALDANE, PRESIDENT, EXECUTIVE JOB COUNSELORS, INC., NEW YORK CITY

Mr. HALDANE. My name is Bernard Haldane, president of the Executive Job Counselors, Inc., of New York.

Representative PRICE. Do you have a prepared statement?

Mr. HALDANE. I have a summary of a statement.

Representative PRICE. Will you proceed.

Mr. HALDANE. As a result of my investigations I am reasonably sure that management practices are largely responsible for the shortage of scientists and engineers.

Representative PRICE. For the purpose of the record and in order to clarify your field, would you describe this association which you are connected with, the Executive Job Counselors, Inc.?

Mr. HALDANE. We have a staff which has interviewed 20-odd thousand people over the past 10 years and reviewed the lives of many thousands more in relation to our research for organizations and individuals on problems related to professional and executive career development. We have been consultants to scientific organizations and educational institutions on their personal development problems, and in general have been concerned with situations relating to how to help people be most effective in their jobs so that the shortage of professional and managerial manpower can be alleviated.

Representative PRICE. Do you give these interviews and make your surveys for private industry under contract, or how do you work?

Mr. HALDANE. We have worked with private industry, public institutions, and on an individual contract basis. At the Society for Advancement of Management conference last week, for instance, I

made a rapid questionnaire study of how members felt about the shortage of scientists and engineers. This is part of the kind of things I do from time to time in order to keep myself posted on what trends are, what problems exist, and how to overcome these problems.

Representative PRICE. You may proceed with your statement.

Mr. HALDANE. Thank you.

I am going to indicate three areas where management practices are very obviously at fault, and give several recommendations on how management can alleviate quickly—by that I mean within a period of 6 months to a year—a large proportion of what is currently called the shortage of scientists and engineers.

I presume that evidence has already been presented to show we cannot expect during the next four years any actual net increase in the number of people holding scientific and engineering degrees. Consequently we have to depend on something other than formal education if we are going to have the scientific and engineering skills that we need now.

Senator Benton, who presented his views earlier, indicated that 70 percent of the students who graduate from high school do not go on to college. A high proportion of these are college graduate material. From these people who do not go on to college, who do not have degrees, we can obtain approximately equivalent numbers of people with the brainpower and the skills to match the number of people we have now with scientific and engineering degrees. We must make the effort to identify and train these people. I think that effort is one mangement should undertake.

Here are the principal management practices that contributed to the shortages.

1. Management is not analyzing scientific and engineering jobs so that segments demanding lesser skills could be allocated to men and women having these lesser skills.

2. Then there is the emphasis on diplomas, rather than on the need for men and women who can get the work done. If management resists the importunings of its own advertising, it will look for equivalency rather than the diplomas—management can't find the diplomas anyway, except by what is commonly called piracy. I think this advertising is very much of a nature that tends to aggravate the shortages. At the IRE convention just a few weeks ago one company advertised a $500 reward for anyone who could turn over to it an engineer, live and warm.

3. I think the failure to establish job classification schedules which assure both financial and status recognition to specialists, without their needing to become supervisors, is something management must correct. This will encourage people to stay in the scientific and engineering fields, whereas now almost half of them tend to move out of those fields. Management, in other words, put engineers and scientists in supervisory positions for which they are not necessarily best qualified, gains inadequate supervision and loses good scientists and engineers.

These practices are strangling our progress. There is one company, for instance, where a desk study of several hundred engineers showed that 70 percent of their time is given to nonengineering work. Such a situation—and it is commonplace—is close to criminal at this time.

I believe we should think in long-range terms, about education, but I think this need for education should not be used by management as a cover for its failure to take intelligent action now. Management should not continue to talk about a shortage of scientists and engineers as long as it has the power and knowledge needed to overcome in very large part the deficiencies of which it complains.

Here are the steps I recommend.

1. Nationwide training and refresher programs to speed availability of needed talents. Some corporations have already embarked on this in a very, very small way. I think Federal support of such a program, perhaps with money it now pays for advertising by corporations for scientists and engineers, would finance it very well.

2. I think a voluntary public program, to identify the men and women who have needed scientific and engineering talents, will go a long way toward making these talents available.

3. Modernization of salary schedules and job classifications, to assure continued recognition for nonmanagerial yet highly talented scientists and engineers, will help keep them working at the jobs they can do best.

4. This business I mentioned before of work simplifiication, reducing the job to its segments, some of which can be allocated to less skilled personnel, is another way of increasing the net availability of scientific and engineering skills.

5. I also think that nonprofit recruitment services without fee to applicants, such as Scientists, Engineers, and Executives Institute of Washington, D. C., will help industry recruit the people it needs all over the country without having to go to the terrific expense—it costs $3,000 a man to advertise for an engineer—the terrific expense needed to pirate men from one company to another.

Representative PRICE. Mr. Haldane, what would be your general overall appraisal of the utilization of scientific and engineering manpower within industry?

Mr. HALDANE. I think if these men were properly used they actually could add between 30 to 40 percent to the availability of skills.

Representative PRICE. That answers my next question. You say they probably could pick up 30 percent gain in this type of manpower with better utilization?

Mr. HALDANE. Yes. Industry is using only about 40 percent of the science and engineering time now available to it in the form of employed personnel; over 60 percent of available time is being applied to activities other than science or engineering. My 30-percent figure is to give some leeway between the maximum available, and what is reasonable to expect.

Representative PRICE. One category that you made reference to which probably is part of that figure would be the use of trained engineering manpower as salesmen and managers. Are we not getting to a point now where that is becoming increasingly more necessary?

Mr. HALDANE. I have included them in my figures.

Representative PRICE. I refer to the use of an engineer as a division manager or office manager or as a salesman. Isn't there some type of work which almost requires a man with this technical knowledge to become a salesman or a division manager?

Mr. HALDANE. There are many instances where that is required, but there are also many instances where sound management analysis of the job would indicate that it would not be required.

Representative PRICE. But where they are doing it.

Mr. HALDANE. They are doing it in many places where it is not at all necessary.

Representative PRICE. In some instances it is necessary. What percentage would you say it is being done where in your opinion it is not necessary?

Mr. HALDANE. Seventy-five percent of the time. I think no more than 25 percent of the time that it is currently done, is it advisable or practical for a good scientist or engineer to be made a manager or salesman.

Representative PRICE. Your type of work is important in the scientific and engineering field, particularly in trying to do something about the problem immediately. Through proper utilization, if we prevent the loss of 30 percent of that manpower, then we will accomplish an immediate result which is important.

Mr. HALDANE. That is what I believe management can do if it applies its normal intelligence to this problem. At the present time it seems to be hiding behind the facade of educational needs. We cannot look for our required engineering and scientific developments in the next 4 years from the existing number of graduate scientists and engineers. We need more. If management is to meet this problem, it must find additional scientists and engineers among the existing people who lack degrees but possess the talent. I have suggested ways by which management can do this.

Representative PRICE. I think you have a good point there, trying to do something about the problem immediately. Do you have a further statement to make?

Mr. HALDANE. No, sir.

Representative PRICE. Thank you very much, Mr. Haldane. We appreciate your cooperation.

The committee will stand in recess until 1:30 this afternoon.

(Whereupon, at 12 o'clock noon the committee was recessed, to reconvene at 1:30 p. m. the same day.)

AFTERNOON SESSION

Representative PRICE. The committee will be in order.

General Smith, will you come around, please?

This is a continuation of the hearing of the Research and Development Subcommittee of the Joint Committee on Atomic Energy on the problem of scientific and engineering manpower shortages, particularly as affects the atomic-energy program.

General Smith, the situation is that we are a little short of members of the committee this afternoon because of the circumstance of the House being in session and other committees meeting at the same time. I want to assure you that I know of the interest of several of the subcommittee members in the engineering problem. I know they will want to look over your testimony very thoroughly.

I also want to say I am sorry to hear about General Sturgis' illness and I hope he gets along all right.

STATEMENT OF BRIG. GEN. C. RODNEY SMITH, ASSISTANT CHIEF OF ENGINEERS FOR PERSONNEL, REPRESENTING LT. GEN. SAMUEL D. STURGIS, JR., CHIEF OF ENGINEERS

General SMITH. General Sturgis is coming along very nicely, thank you, Mr. Price. General Sturgis has asked that I tell you how much he appreciated receiving your kind invitation to appear before this committee to testify on the problems of engineering and scientific manpower. He deeply regrets his inability to be here. Nothing but the most positive doctor's orders could have prevented him from coming here today. Ever since he became Chief of Engineers, General Sturgis has felt very strongly that of all the problems facing the United States Army Corps of Engineers, the continuing and increasing shortage of engineering manpower ranks at the top.

As he stated in his letter acknowledging your cordial invitation to appear before your committee, he holds the strong conviction that if the Corps of Engineers is to maintain in the future the high standards which it has constantly striven to attain, it is absolutely essential that an answer be found to alleviate engineering manpower shortages. General Sturgis is highly encouraged by the interest of your committee, and the opportunity it affords for finding ways to overcome the shortage of engineers and scientists. As General Sturgis' assistant for personnel, I will attempt to summarize the views which he has passed along to me in this regard.

Today's ever-increasing emphasis on technical advancement both in civilian and military pursuits, has placed an unprecedented premium on engineering talent. The acute national shortage of professional engineers has been reflected so markedly in the Corps of Engineers that it has become a matter of great concern to the Chief of Engineers. It is essential in the interests of national defense that before growing deficiencies assume more dangerous proportions, positive steps be taken to halt the steady trend toward greater shortages and overcome the increasing difficulties currently being experienced in maintaining a strong corps of military and civilian professional engineers.

The Corps of Engineers is the largest Federal employer of professional civilian engineers. We have a total of about 55,000 civilian employees, of which approximately 8,200 are professional engineers and another 8,000 or so are subprofessional technicians, engineering aides, engineering draftsmen, construction inspectors, and so forth. Together with some 9,000 engineer officers, and more than 100,000 enlisted men, these 55,000 civilians are employed on the worldwide construction and military activities of the Corps of Engineers: the civil-works program, military construction for the Army and Air Force, and a wide variety of military activities of both a troop combat and technical service nature. At various times over one-half of our civilian engineers are engaged on civil-works projects.

It is becoming increasingly difficult for the Corps of Engineers to hire the engineering talent it requires. Evidence of the serious proportions of this problem is found in the mounting number of unfilled vacancies. At the end of 1955 the total number of requisitions on hand for civilian engineers which we had not been able to fill had risen to 505. During the first quarter of 1956, this total of unfilled vacancies rose to 657. A large share of these 657 vacancies have re-

mained unfilled for long periods, despite coordinated efforts to fill them throughout our entire field organization.

I have shown these figures graphically on this chart. While not large, it is the significance of the trend which I wish to point out particularly. Let me repeat, the constantly increasing mounting backlog of unfilled vacancies for engineers rose by 152 in the first 3 months of this year, to a total of 657, again emphasizing this is a trend.

While out of 8,000 engineers this in itself does not represent a considerable percentage, it is this constant trend and this accelerating trend which has us particularly concerned.

These vacancies range in grades all the way from GS–5 to GS–13. The peak is around the GS–9/10 area. It is alarming that 158 of the vacancies, representing 25 percent, are in grade GS–11, where our difficulty in attracting and holding experienced engineers is particularly acute.

I want to emphasize that I am speaking of purely professional enginers, not the subprofessionals or technicians, but the actual engineering graduates or men who have acquired through experience professional competence in engineering.

During this same first quarter of 1956, civilian engineer losses totaled 280 as compared to 210 during the preceding quarter. Again this is the trend which I wash to emphasize. The proportion of these losses known to have gone to private industry or self-employment during the first 3 months of 1956 was 50 percent greater than in the preceding 3 months. Current difficulties of the Corps of Engineers in hiring the civilian engineers needed to fill existing vacancies are illustrated by the following figures obtained from a representative sampling survey of approximately 25 percent of our field installation strength, covering the first quarter of 1956. Of 1,164 definite offers of employment made to qualified prospects, 1,112 were declined and only 52 out of the 1,164 offers were accepted.

Representative PRICE. General, do you have a survey as to the reason for the declinations?

General SMITH. No, sir; no specific facts. The reasons are normally kept to the individuals themselves. Our belief is that the basic problem, as I will come to in a moment, is one of salary, that the salary we could offer was simply not attractive enough to bring them in. Our jobs are interesting and very challenging from an engineering viewpoint and offer a wide variety of engineering work. We believe that our working conditions, which we have carefully examined, and the nature of our work are such as to attract these engineers. We do not find declinations on that basis. We have come to the conclusion that it is a matter of the amount we can pay them.

Corps of Engineers vacancies are most numerous in positions for civil engineers and closely related fields, but we have urgent unfilled requirements for nearly every type of specialist in the engineering profession. In the first 3 months of 1956 we were not able to hire a single man in the fields of hydraulic, sanitary, highway, or chemical engineering, despite active recruiting in an effort to fill 48 open positions in these categories. During this period jobs were offered to 191 engineers qualified for such positions, but all were declined.

The shortages of engineering manpower are significantly worse in the research and development activities of the Corps of Engineers

than in any other segment of our work. Vacancies in engineering positions at the Engineer Research and Development Laboratories at Fort Belvoir, our largest R. & D. activity, amount to 11 percent of the total number of filled engineering positions. This corpswide figure is 8 percent. For every new employee hired for an engineering job at the laboratories during the first 3 months of this year, 5 such positions still remained vacant at the end of the quarter.

Representative PRICE. In these references to Fort Belvoir, General, you are not taking into consideration personnel under private contract?

General SMITH. No, sir; these are only Government civil-service positions that I am referring to. The situation of employees under contract is an additional and separate matter.

At the Engineer Research and Development Laboratories offers of employment were tendered to 438 qualified prospects during this period, but only 9 were accepted and 429 were declined.

I believe that the fact that we are in a worse situation in the research and development field would be of particular interest to your committee.

Representative PRICE. General, what type of personnel are you referring to when you talk about your research and development?

General SMITH. A wide variety of engineering and research people, scientific people, for various types of research and development activity, including the development of the atomic powerplant. Our research and development activities range throughout the whole area of engineer equipment, construction equipment and military troop equipment.

A typical example of what we are up against in maintaining an adequate research and development staff is seen in the recent hiring by a commercial firm of three electronic engineers who were employed at the Engineer R. & D. Laboratories. This civilian firm gave at least one of these men a starting salary 50 percent higher than he was earning at the laboratories. At least one of these engineers is now working on a Government contract. Thus the Government is in effect paying him more to work as an employee of private industry than we could pay him as a Federal employee. Meanwhile, there is a steady increase in the magnitude and complexity of the Corps of Engineers' research and development program, which includes development of the Army's nuclear powerplant. As recruitment falls more and more behind, mounting losses of engineers to private industry further reduces our research and development staffs. We are today still able to do an effective job, but the trend for the near future gives us real cause for concern.

The continued vitality of the civilian force of the Corps of Engineers can be maintained only by the annual recruitment of a large number of young engineering college graduates coming in at the bottom as junior engineers. This new young blood for a force of over 8,000 engineers should total 500 or more each year. Last year we made an intensive drive for a minimum of at least 300, but we fell far short. Despite an active and progressive recruiting campaign, we succeeded in hiring only 194 engineers from the 1955 graduating classes. With industry offering even higher salaries this year, advance reports from our field divisions indicate that we are apt to fall further

short. Despite an active and progressive recruiting campaign, we serious discrepancy between the number of young college graduates we need and the number we can get is shown graphically by these bars on the right hand side of this chart.

With an annual requirement of 500 junior engineers as a minimum, we hired in 1955 only 194. Our estimates of hires of junior engineers for 1956 are falling even lower, and there are many indications that we may not be able to obtain more than one-fourth of our desired figure this year, even though we have redoubled our recruiting efforts. It is emphasized that these figures pertain only to young graduate engineers. Our total annual requirement for engineers in all grades is approximateley 1,000.

These recruiting efforts include visits to all of the engineering colleges in the country and discussions with the undergraduates and men who graduate this year, of the opportunities in the Corps of Engineers under our junior engineer vocational training program. We have a colored film which shows very vividly the kind of work and the attractiveness of the work in the Corps of Engineers. We have descriptive literature which in the aggregate constitutes a very progressive recruiting program. We don't just sit and wait for these men to come and apply to us. We go out after them and are seeking to get them. Despite that, those figures show how far short we are falling.

This inability of the Government to hire the engineers it needs is more than anything else a matter of salary. With the available supply of engineers far lower than total demands, industry has raised its salary scales and other inducements to such a level that Government pay rates are simply no longer adequate to compete effectively in the employment market. The illustrative shortage figures there on the chart speak for themselves in emphasizing how important it has become for the Government to take positive steps to improve its position competitively with industry in hiring the engineering talent necessary for execution of Government business.

The higher salaries offered by industry are attested by numerous surveys and by the many advertisements for engineers to be found in almost any newspaper at salaries well above Federal pay schedules. In addition to salaries, industry is offering fringe benefits and other inducements which are not equaled by the Government. Business firms have developed recruiting programs of great vitality and intensity. Coupled with industry's attractive salaries, the Government is in danger of being left completely out in the cold. The Corps of Engineers has a vigorous and well-organized recruitment program, and we offer a wide variety of challenging and interesting engineering assignments, but the amounts we can pay just do not compare with the greater pay commercial firms are offering under current conditions of a scarcity of engineers.

Until the national shortage of engineers can be alleviated, the Government will continue to be faced with the stiffest competition in attempting to hire engineers. If this competition is to be met successfully, the Government must provide further incentives, particularly higher pay schedules, enhanced status for engineers, and a greater number of top grade positions at the GS–16, 17, and 18 level.

The entire Corps of Engineers has been authorized only 2 GS–17's

and 4 GS–16's—no GS–18's and no Public Law 313 high level scientific positions for research and development activities.

I would like to bring out in connection with this that our annual budget is running approximately $2 billion, yet for that vast program that we are to carry on as the largest Federal employer of engineers, we have a total of only six positions above grade 15.

Representative PRICE. What is the reason for that? Did the Chief of Engineers ever request a higher classification?

General SMITH. Yes, sir. Over a long period the Chief of Engineers has requested greater numbers. The Department of Defense and the Army have a limited ceiling. This year the Department of Defense recommended to the Congress and there is pending before committees now a bill to increase the number of higher level grades both in the Public Law 313 field and in the so-called super-grade field.

Representative PRICE. In other words, it wouldn't be prorated on the basis of branch? Within the Defense Establishment is there any leeway that more of these classifications could be allocated to the engineers without additional laws?

General SMITH. There are not now open unfilled allotments that the Department of Defense has in any appreciable numbers which could be used to alleviate this position. Due to vigorous efforts of the Chief of Engineers to present the priority of his requirement to the Army and the Department of Defense, during the past year we have received three additional super grades. We previously had only three, and we now have had that doubled in the past year. That has been due to legislative enactment in one case, and to availability of additional spaces in the Department of the Army in two cases. But it is only a beginning. Frankly, we in the engineers, without pointing a finger at anyone, feel that there is often too much attention given to the managerial or comptroller or executive type of position in allocating these super grades rather than to the engineer. We feel that engineers in the past have not been given as large a share of the available quotas as might have been done. But the real problem is not there. It is greater ceiling allocations to the Department of Defense which require congressional action.

Representative PRICE. Who is the top R. & D. officer and civilian in the Corps of Engineers?

General SMITH. Who is the top?

Representative PRICE. Yes.

General SMITH. We have several research and development organizations. Our major one is the Engineer Research and Development Laboratories at Fort Belvoir. A Colonel Sykes is the director. He serves under the head of the laboratory, who is the commanding general at Fort Belvoir, a major general. The commanding general functions directly under the Chief of Engineers and his staff. On the staff of the Chief of Engineers, there is a brigadier general who exercises general staff supervision over the research and development work. So we have a chain there from the Chief of Engineers through his staff and through the commanding general at Fort Belvoir to the colonel directly in charge of the laboratory. We have one GS–16 civilian as the senior civilian in that laboratory.

Representative PRICE. GS–16?

General SMITH. That was recently allocated as a result of very vigorous efforts by General Sturgis.

Representative PRICE. Is he equivalent to manager of the laboratory?

General SMITH. He is actually the technical director under the colonel who is the overall manager or director. It is a sort of team between the military and the civilian, but the military man is the head man. Of the civilian staff, this GS–16 is the senior man.

Representative PRICE. Do they have military supervision over the AEC project, then?

General SMITH. The AEC project is handled under a special group.

Representative PRICE. Not under these?

General SMITH. Not directly under the laboratory. It is handled as a special function under staff supervision of the Chief of Engineers and under another colonel, a separate colonel from the one at the laboratory. There is close integration and collaboration with the laboratory but it is handled as a separate entity.

Representative PRICE. Proceed.

General SMITH. Considering that the Corps of Engineers employs 55,000 civilians of whom 8,200 are engineers, this total of only 6 higher grade positions in salary brackets above $12,000 results in a dearth of opportunity for promotion for our top professional engineers and a serious lack of recognition and prestige for outstanding men who have built up national and, in fact, international reputations in the engineering world.

I am speaking there not merely of our research and development activity but of our worldwide construction activity, where we have many leading civilian engineers, none of whom in the field organizations has a super grade position.

The adverse effect of this negligible number of high level grades is felt far down the line. Without a reasonable proportion of top grades, insufficient incentive is provided for lower grade employees. This leads some of our best qualified professional engineers to seek positions outside the Government service, where they will have greater promotion and pay opportunities.

An additional point of genuine importance is the matter of professional prestige. Engineers are proud of their professional status. They wish to be recognized and identified as members of the engineering profession. They are acutely conscious of the fact that some years back the Government incorporated all civil-service personnel into a single general service classification, with standardized designations and pay scales applicable alike to professional and nonprofessional employees. In contrast, industry has increasingly emphasized the importance of according greater professional recognition to engineers.

So far my remarks have been addressed principally to shortages and problems relating to civilian engineers. However, the engineering manpower problems of the Corps of Engineers are equally if not even more significant on the military side. Here too the national shortage of engineers has seriously affected our ability to attract and retain an adequate number of officers with professional engineering education and experience.

Four-fifths of our active duty commissioned personnel are Reserve officers. We have great difficulty retaining on active duty a sufficient

proportion of Reserve officers who are professional engineers. The ROTC graduates who serve for two obligatory years on active duty are largely graduate engineers and are fine young officers. But only about 10 percent of these officers elect to continue their Army careers and remain on active duty beyond the expiration date of their mandatory tours. Even among our Regular career officers, resignations and voluntary early retirements are excessively high. The reasons for this situation are much the same as already discussed on the civilian side, with additional problems created by overseas assignments, inadequate housing at remote stations, and inadequate or uncertain facilities for the care of families.

To counteract and overcome these difficulties, there is need for higher pay, better housing, increased fringe benefits, and passage of the officer augmentation bill recommended by the Department of Defense and the President. Authorization of the integration of substantial numbers of Reserve officers into the Regular Army, with the attendant improvement in officers' career advantages, is badly needed to attract a higher percentage of the best engineers among our Reserve officers to stay on for a career in the Army Corps of Engineers. Passage of this bill will do more than any other single thing to pave the way for improvement of the engineer officer situation.

The Chief of Engineers has taken many vigorous actions to alleviate his engineering manpower problems to the maximum extent possible within his own capabilities and authority. Improvements in personnel procedures and utilization are constantly being sought out and followed through. Whenever possible, engineering talent is being conserved by not wasting it on nonengineering duties. We seek to make maximum use of subprofessional technicians. In keeping with the traditional policy of the Corps of Engineers, we contract for as much of our engineering work as is feasible. We conduct training programs and send substantial numbers of officers and civilian employees to attend technical engineering courses. Our on-the-job training program for junior engineers has been highly successful and we exploit it to the fullest in attracting and developing young new employees.

Effective use is made in engineering and research work of all the inductees we can lay our hands on who qualify by professional engineering education and experience for assignment under "SPP," the Army's scientific and professional personnel program. Looking toward the long-range future, we are studying the application of electronic computers to engineering problems as a means for freeing engineers for other duty. From the very beginning of his tour as Chief of Engineers, General Sturgis has strongly advocated and supported every opportunity to make the military and civilian careers of all Corps of Engineers personnel more attractive and to develop every individual's engineering capabilities to the fullest.

Much progress has been made through these actions to improve our situation ourselves. But in the face of the overwhelming impact of the acute and growing national shortage of engineers, our own "Operation Bootstrap" is not enough. Outside assistance of two basic types is needed. First, assistance is needed from the Congress to authorize higher Federal pay schedules for engineers and scientists which will enable the Government to compete with industry for a fair share of

today's short supply of engineering manpower. Second, as a broad and long-range requirement, effective and practical ways must be found for producing far greater numbers of engineers and scientists in the United States in future years so as to overcome progressively the insufficient national supply.

May I sum up the views of the Chief of Engineers regarding the engineering manpower situation in the Corps of Engineers by re-emphasizing the following points:

1. The clearly defined trend of increasing shortages of engineers and scientists in the Federal Government has reached such proportions that, unless effectively checked and reversed at a very early date, vital national security programs and our mobilization readiness will be jeopardized.

2. During the past few years private industry has substantially increased the salaries paid to engineers and scientists. These salary increases for engineers were long needed and are a healthy incentive toward encouraging greater numbers to follow engineering careers. However, Federal salaries for engineers and scientists have not kept pace with industry and are now comparatively so far behind that Federal employment suffers a major competitive disadvantage.

3. The current status of increased difficulty in Federal employment of engineers and scientists and the accelerated losses to private industry now being experienced are so marked as to give great emphasis to the need for immediate action to establish higher Federal pay schedules for engineers and scientists. The higher pay scales recommended for engineers and scientists in Government need to be applied from the bottom to the top of the entire grade structure, all the way from beginning rates to the top steps of senior grades.

4. In addition to higher pay scales throughout the grade structure, the Corps of Engineers also urgently needs a proper proportion of the highest level grades in the GS–16, 17, and 18 area and a number of Public Law 313 positions. Increased numbers of these positions have been recommended by the Department of Defense.

5. Coupled with an improved pay and grade structure, commensurate recognition needs to be given to the professional character of engineers and scientists in Government service, with appropriate designations to define such status.

6. The constantly increasing demands for more and more engineers and scientists are so far outdistancing available supply that it has become clear that positive and organized measures are required to promote a larger annual production of engineers and scientists from our national educational system. This field is, of course, beyond the purview of military responsibilities, and determination of the steps appropriate for the Federal Government to take in this regard rests with groups such as your distinguished committee and the National Committee for the Development of Scientists and Engineers established by the President last month. From the viewpoint of the Corps of Engineers it seems highly desirable that as a part of such consideration ways be sought to encourage and guide a fair share of each year's engineering graduates into Federal employment.

It is hoped that this presentation of the facts regarding the serious nature of the problems which confront the Corps of Engineers in maintaining a strong and vigorous engineering work force in the face

of today's national shortages may be of some value to your committee. We sincerely feel that there is real urgency in the need for immediate action to improve the status of professional engineers in the Federal service, and for specific long-range measures for increasing the national supply of engineers. We look forward with anticipation to the results of the work of your committee in finding solutions to these problems.

If any of you have questions, we will do our best to furnish you either now or later any information which you may require.

Representative PRICE. Thank you, General. That is a fine statement. The committee certainly considers it valuable, and appreciates your cooperation.

You lay great stress on the differential between the wage scale of industry and that offered in Government for engineering talent. Assuming that we are talking about the engineer with the same qualifications, could you give us some comparison of what a man is getting from the Corps of Engineers and what he might be getting if he were working outside in private industry?

For instance, what are you able to offer a young graduate engineer when he comes into the Corps?

General SMITH. We have not made a comprehensive study of this field. However, there are certain immediate differentials which are very evident. For the young graduate engineer, the man we are talking about here, that we are trying to hire to the tune of at least 500 a year and are getting perhaps a fourth of that this year, starting salaries offered by industry appear to range from around $400 upward this year. There is considerable deviation in what is offered different kinds of engineers at different schools, different sections of the country, and in different sections of the classes.

Representative DURHAM. You mean per month?

General SMITH. $400 per month as a minimum and ranging on up to $475.

Mr. Benjamin Fine of the New York Times has published 2 or 3 analyses of his surveys of starting rates this year, and those comments speak of the range going up from around $405 for men with a bachelor's degree to $475 for a master's degree, and $655 for a doctor's degree. That was a recent analysis of his.

We find that our salary rates which we can offer now are far below that. The junior engineer that we can hire as a GS–5 we can now give around $373 a month by virtue of the Civil Service Commission having stepped up the initial hiring rate under authorization of law granted them last year, to the highest step. We can now hire junior engineers in Grade 5 and then promote them later to Grade 7 in the highest step, the seventh step of the Civil Service pay scale. $373 is the highest we can offer these college graduates initially.

Representative DURHAM. You are speaking now entirely of the civilian end of the engineering corps; are you not?

General SMITH. Yes, sir. Going on up, our highest regular step in grade 15 would be $12,690 a year. I had been talking about $373 a month, which is $4,480 a year. We range now from $4,480 to $12,690.

Representative DURHAM. Is that your top pay?

General SMITH. That is our top pay for all but six people in the Corps of Engineers, all but the six higher level, the four 16's and the

two 17's that I referred to. For all practical purposes the top salary for our GS–15 employees is $12,690.

Many of those top engineers have national and even international reputations.

Representative PRICE. How long does it usually take them to reach that top figure?

General SMITH. Perhaps 20 years.

Let me ask my assistant here, Mr. Jacobs, Chief of Civilian Personnel, about what the average would be to reach the top grade.

Mr. ROBERT F. JACOBS (Chief, Civilian Personnel Division, Office, Chief of Engineers). To reach 15? Our engineers to reach grade 15 usually have had 20 to 25 years of service, sir. Of course the entrance rate in grade 15 is $11,610, and then there are in-grade step increases each 18 months. It requires 6 years in grade 15 in order for them to progress up to $12,690.

Representative DURHAM. You could hire those direct from civilian service, could you not, at that salary?

General SMITH. Yes, sir; if we could hire them.

Mr. JACOBS. $11,610, yes.

Representative DURHAM. There is nothing to prevent your paying them that sum of money provided you can secure the engineers somewhere. You have a number in grade 15 at the present time. Are you limited on numbers in that category?

General SMITH. We are limited on numbers, but of course the numbers in any given grade vary by the nature of the work. We have overall ceiling allocations numerically, but the individual grades vary depending on the type of work and the responsibilities which they have.

Representative DURHAM. Can you tell us the pay that the military service personal receives in comparison to this? Is it in line?

General SMITH. The military service base pay of a second lieutenant starts in at $222.30 a month.

Representative DURHAM. He has the same qualifications as the boy that you take in at $373; is that correct?

General SMITH. Yes, sir. To the $222.30 a month is added a quarters allowance of $85.50 if he has dependents, and $68.40 if he has no dependents.

Representative DURHAM. That makes his total pay how much as compared to the civilian engineer?

General SMITH. I will have to add to this——

Representative DURHAM. What I am trying to get at is to see whether the same thing applies to your military personnel as applies to your civilian personnel as far as pay is concerned. It affects both.

General SMITH. It does affect both. It is a little difficult to make direct comparisons because the retirement system is somewhat different. The quarters allowance and the subsistence allowance of some $40 which is given are exempt from income tax. So there is difficulty in making an exact comparison.

Representative DURHAM. There is a differential?

General SMITH. I would say that our second lieutenant entering the service has roughly the same pay as the junior engineer coming in. The pay is basically equivalent. If he gets up to the grade of colonel he is probably earning somewhat more money, when you consider the tax exemption, than an average civilian of like length of service.

Representative DURHAM. A grade 16 would be about the same as the colonel?

General SMITH. I would say a grade 16 is probably earning more money in the aggregate lump payment than the colonel, but when you consider the allowances and the income tax exemption and the better retirement pay, that is compensated for.

To go back and answer your basic question, Mr. Durham, I believe that at present the best rough estimate we can make is that our range of civilian salaries is running, starting at least 10 or 15 percent differential and running up to about a 25 percent differential below salaries paid by industry on the average up and down the line for the run-of-the-mill grades. Where we fall down, though, is that we have little opportunity for promotion over the $12,600 area and therefore some of our very top engineers cannot begin to compare with the salaries offered outside for such men.

Representative DURHAM. Having had the experience, would you say that the differential in the civilian work was taking off what you might call the cream of the crop from the Army Engineers at the present time?

General SMITH. The higher salaries offered by industry today are definitely taking the cream of the crop away from both our civilian engineering employee field and our military. I would like to explain that in this way for the military: The young ROTC engineer graduate who comes into the military service for 2 years will not stay on in any appreciable numbers in the Army because they can get more pay by going into civilian engineering activity on the outside.

Representative DURHAM. How many resignations have you had in the last 12 months in the civilian end of your personnel? Could you give us that?

General SMITH. No, sir; I do not have that figure for the last 12 months. I have a comparison between our losses for the last 3 months with the preceding 3 months.

Representative DURHAM. Well, 3 months is all right.

General SMITH. I do not have it for the year's period.

Representative DURHAM. I did not hear the first part of your statement.

General SMITH. In the first quarter of 1956 our civilian engineer losses totalled 280. The preceding 3-month period it was 210.

Representative DURHAM. Going up?

General SMITH. It is going up. It is that trend which is causing us the greatest concern.

Representative DURHAM. Of course I don't think that is going to solve all of our problems in the engineering profession. We have simply to produce more engineers, as I see it, from somewhere.

General SMITH. The basic problem is to produce more engineers. We feel that there is a real problem there for the Federal service generally and for the Corps of Engineers. As I said in my prepared statement, we feel that the broad question of how to produce and obtain greater numbers of engineers nationally lies outside our field, but we do feel that there should be something done in the way of encouraging undergraduates in the engineering field to follow the engineering field in the first place, and to come to the Government service in the second place.

Representative DURHAM. I am not familiar with the duties of this committee appointed by the President 2 weeks ago. What are their duties? Is their job to make a study and recommend to the President?

General SMITH. Yes, sir; it is to make a study and such recommendations as it sees fit. The letter from the President to Dr. Howard Landis Bevis, the chairman of this committee, which the President issued on the third of April, referred to the losses that had occurred through the reduction in and failure to produce the number of engineers, our continuing shortages of engineers and scientists and then said this:

> I established some time ago a special interdepartmental committee to make an intensive study of the situation. This committee has now made recommendations to me on actions which might appropriately be taken by the Federal Government to improve our relative position. At the same time the special committee pointed out that the problem of increasing our supply of qualified scientists and engineers cannot be solved by Government alone. The committee wisely recognized that the problem required for its solution the powerful and concerted action of citizens and the citizens groups organized to act effectively.

That is the basic purpose behind this.

He then expressed his hope that the committee would first assist the Federal Government in identifying the problems associated with the development of more highly qualified engineers and scientists, second, enlist the cooperation of all interested individuals and groups in analyzing the problem and in developing programs to deal with it and to take the lead in the coordination of interested organizations outside the Federal Government, and then to make available to those organizations information on effective ways to publicize the solutions which they arrive at, and to provide the President with reports on progress from time to time.

Thus, this is an effort to coordinate the citizens groups outside the Federal Government area in seeking a long-term solution to this problem.

Representative DURHAM. The Federal Government continutes to impose more responsibilities on your corps. That has been a continuous thing for the last several years that I have been around here.

General SMITH. That is true, sir.

Representative DURHAM. What is the number of your corps at the present time?

General SMITH. Our civilian employees total 55,000 at the present time. Our officers are about 9,000.

Representative DURHAM. Are you able to perform all the duties imposed on you by the Congress this year?

General SMITH. We are able to date to take care of our duties effectively. We are worried about the future because of the continuing trend of increasing losses and of our inability to hire.

Our requirements are going up, and our need for engineers is going up. This may answer one of your earlier questions a little better. We are turning over now between 10 and 12 percent annually, of our engineer force of 8,200.

Representative DURHAM. Does that include your retirement, too?

General SMITH. Yes, sir.

I would like to develop your other question for a moment. You asked if we are able to do our work. That becomes a very pertinent question in the face of these alarming shortages which are developing.

We believe we are still fully capable of executing the missions the Congress has assigned to us and executing them effectively, but it is the preservation of that ability we are concerned with. It is becoming harder and harder each month. I spoke before you came in of the fact that we had offered jobs in one representative area during a 3-month period to 1,164 people, but had gotten only 52 acceptances. That illustrates the additional effort which is required today to maintain our force. We are concerned about the increasing age of our force. One of the things that makes it possible for us to continue to do our work effectively today is that we got back in the thirties a fine bunch of engineers who are now our senior top people and are staying on. They have a loyalty and an interest in our work. They are part of our team. Also they have a real investment in their retirement which is built up. They are not leaving us in the same proportion as are the younger men with 6, 8, or 10 years' service, who get up to GS–11 grade or something like that and see the difficulty of promotion to higher pay and see the higher pay offered in civilian life. They leave us at that stage. As soon as we lose these senior top engineers we have through retirement, and they are now getting fairly old, we are going to be in trouble unless we have brought in new blood from the bottom and middle areas.

Representative DURHAM. I happen to know two or three young men who were retired because of disabilities rather young. Do you ever think of surveying that field to see whether or not they have been restored enough so they can perform some duty? Has any thought been given to that?

General SMITH. Are you speaking of the military or civilian fields?

Representative DURHAM. I am talking of military and civilian, both, because you have both.

General SMITH. The difficulties of hiring retired military people——

Representative DURHAM. I am talking about the physically retired, not because of age but because of some disorder.

General SMITH. The Dual Compensation Act limits the attractiveness of employment even for physically disabled military people. A great many of our engineer officers are retiring even with 30 years' service not physically disabled, but again they cannot be employed by the Government because of the Dual Compensation Act restrictions.

Any civilian engineer who regains health, if he left the service because of health, would certainly be a source of supply for us which would be exploited to any extent that we could. I do not believe we have any major opportunities in that field, Mr. Durham. I don't believe it offers a major alleviation.

Representative DURHAM. When you are scraping the bottom of the barrel you have to look everywhere.

General SMITH. Yes, sir. Every possible avenue has to be explored.

Representative DURHAM. Can you tell us how many engineering colleges there are in the country at the present time? I don't happen to know.

General SMITH. No, sir; I cannot. Can any of my staff do that? I am sorry, I do not have that information.

Representative DURHAM. Can you tell us the potential graduates this year? Do you possess that information?

General SMITH. I do not have those figures available here. I have read reports and I believe the figures are somewhere in the 26,000 to 30,000 area of number of engineers graduating.

Representative DURHAM. You face a very serious problem.

General SMITH. I don't have the total number. I can't give you the total number of colleges, sir.

Representative DURHAM. Would you think it wise for the Federal Government to initiate a scholarship plan of some type at the present time?

General SMITH. We have thought a lot about that from our own viewpoint, Mr. Durham. As I said in my prepared statement, we recognize this is not really a question that the military have a prime cognizance over, but the Chief of Engineers has urged consideration by appropriate agencies of a competitive scholarship program to encourage students to pursue accredited engineering courses——

Representative DURHAM. At what level? High school?

General SMITH. At the college level. That is, graduates of high school going on into college engineering courses—whereby the Government on a competitive basis, would provide tuition and allowances for qualified students who would agree to serve a minimum of 4 years in the Government service upon graduation. This is an idea which we have proposed because of our great difficulty in recruiting the number of engineering graduates from colleges.

Representative DURHAM. We do that at our military school, at West Point, now.

General SMITH. In a sense, yes, sir; and the Navy does it under the Holloway plan in a sense. I made a note on that point, sir. This note I would like to read into the record.

We believe this type of scholarship, a specific scholarship program for the Government's specific needs, direct needs, with a tag of a period of Government service attached to it would offer many advantages without involving the overall question of educational subsidies. It would stimulate interest in engineering courses among high-school students, but on a competitive basis. It would help increase the annual output of engineering graduates. It would funnel increased numbers of college graduates into the Federal engineering work.

What we have in mind is a modification of the Navy's Holloway plan for officers applied to civilian engineers.

Representative DURHAM. That has certainly worked.

General SMITH. Our Chief of Engineers, General Sturgis, feels strongly that such a plan is urgently needed to provide a flow of young engineers in at the bottom, which is vitally important to our continued vitality and the competence of our engineering force. This current inability of ours to obtain even half of the young college graduates we need each year, despite our most vigorous recruiting programs, highlights the necessity of turning to some new approach and of taking some sort of forward looking action to solve this problem. We believe there are real possibilities in the proposal to send engineering students to college at Government expense in return for a period of Government service, say 4 years.

Representative DURHAM. We imposed on you this year quite a duty in construction for the military. I suppose when the Department makes a proposal for such a tremendous sum of construction as it has been doing for the last several years, it asks you whether or not you

can perform your duties? Are you taking this into consideration at all when we take on all these construction items throughout the world?

General SMITH. Yes, sir; we are. We still feel up to right now that we are capable of doing it.

Representative DURHAM. And you are running a shortage of 50 percent a year at the present time, you say?

General SMITH. Of new blood coming in at the bottom, yes, sir.

Representative DURHAM. In other words, you are getting 50 percent of what you desire.

General SMITH. Not even 50 percent.

Representative DURHAM. How long will that continue before you will have to tell somebody, "Here, I can't perform this duty"?

General SMITH. Not long, not many years longer.

Representative DURHAM. Could you hazard a guess as to how long?

General SMITH. I would hazard this guess, sir, and it is purely a guess: That on the basis of the trends which have shown up during the last year of increasing losses and decreasing employments, more and more difficulty in employing, and the fact that in the next 6 to 10 years our age group will get to the point of increased retirements, I feel that 6 to 10 years from now will be extremely critical. That is why we feel that something like this modified Holloway plan might be very valuable. It would start producing for us about 5 years from now. That is not soon enough, but at least it will mean reversing the trend. It has the possibility of reversing the trend.

Sir, I am emphasizing throughout this statement, and General Sturgis emphasizes there is a need for immediate action. The Holloway plan or idea that I speak of is long-range, a part of the national program of increasing the supply. We need in the Government service short-range action, too. We need this year an increased pay schedule. If, for example, there were a 10-percent or a 15-percent increase in pay schedule this year, we would be able to held this trend of not being able to hire, and then that pay schedule should be studied each year to determine what it really ought to be on a national basis.

Representative DURHAM. That is merely a way to meet your competition with private enterprise.

General SMITH. That is right.

Representative DURHAM. It doesn't add any more engineers. It may give you more engineers, but you would have to take them from the New York advertisements which appear. The other plan is the No. 1 recommendation, and the other is some type of scholarship plan of inducement.

General SMITH. Yes, sir. Not just the scholarship plan, sir. We feel just as the President's committee envisages and as no doubt your committee has received many recommendations, there are many ways that it may be possible to publicize this and get the whole country behind more and more young students taking engineering.

Representative DURHAM. Salaries by the Federal Government would have some effect on a boy's desire to take engineering. It would have some effect, but I think probably the best idea is a scholarship or some long-range plan.

General SMITH. It is absolutely essential to get down to some grassroots plan which will produce greater numbers, but I do want to emphasize, Mr. Durham, that that is longrange at best. That will not

be effective for us for 5 to 10 years in any appreciable numbers. Meanwhile, the Government cannot sit back and let the entire available supply go to industry alone. We must do something to reserve our own position in the Government as a stopgap interim measure while the longer range measures are being taken to increase the number of engineers.

Representative DURHAM. Don't you think if we meet private enterprise salaries, we are just simply going to go up the ladder? There is no end to this thing on that kind of basis. It doesn't solve the problem at all.

General SMITH. You are absolutely right, sir. It does not solve the problem. It is only an interim measure, and it continues spiraling. The only good effect of that is that, within reason, the long-needed increase in salaries for engineers does offer a real incentive to the student to take up engineering.

Representative PRICE. General, what percentage of your ROTC boys after they complete their 2 years of service then go into your organization as civilian engineers?

General SMITH. A very small percent, sir; a negligible percent. We are carrying on a recruiting program in that field. When our ROTC 2-year man does not elect to stay on longer, does not seek to stay on longer, we immediately contact him with regard to civilian employment and we seek to bring him into our civilian fold. But we are not getting any appreciable numbers.

Representative PRICE. You stated that your annual requirement for civilian engineers, new engineers, were about 500 a year, of which you are able to recruit less than 50 percent. What is your annual requirement for officer engineer personnel?

General SMITH. Around 1,500 because of the 2-year people who do not elect to stay in the service in any greater numbers than about 10 percent. Let me check that with Ploger.

Is 1,500 for next year about right? For the last 2 years it was about 1,500. It would not be that large of course if it were not for the losses, if more of these people would stay on for longer than 2 years.

Representative PRICE. How many of these people come to you from the military academy?

General SMITH. This year 46 will come to us from the military academy, and between 40 and 60 would be the normal figure to anticipate.

Representative PRICE. With what degree do they come out of the military academy?

General SMITH. They come out with a bachelor of science degree, but they lack certain technical engineering subjects which we then supplement for most of the academy graduates by sending them to a civilian engineering school for 9 to 12 months, usually, somewhere in their third to eighth year of service, at which time they gain usually a master's degree, but sometimes a bachelor's degree in engineering——

Representative PRICE. You can't hope, then, to take care of your military situation predominantly through the military academy?

General SMITH. No, sir; it is a very small percentage. It is a very important element of a hard core for our continued Regular Army, but a very small percentage.

Representative PRICE. I am surprised and amazed at those figures. I would have guessed there were considerably more than that.

General SMITH. The Corps of Engineers has roughly 10 percent of the officer strength of the Army, 8 to 10 percent. We get 13 percent of the military academy graduates. The military academy graduates are divided up among the various combat arms and do not all go to the technical services. The output is so small annually. The graduating classes run from 450 to 400, roughly. Our need in the engineers alone at the present time is, as I said, 1,500 because of our turnover.

Representative PRICE. Could you give me some figures on how many engineers you lost last year to private industry?

General SMITH. Civilian engineers? No, sir; I do not have last year's figures from our organization as a whole. We have a very decentralized organization. It was only in the last two quarters that we began to bring in from all of our field organizations comprehensive reports which will give us the entire figure. For instance, in the last quarter 94 of the civilian engineers who left the service stated as their reason that they were leaving to go to private industry or self-employment. Many others who left the service did not state their reasons. Most of them who left, of course, went to go into private industry, but they did not state it. They are not required to.

Representative PRICE. But you are certain that at least 94 last year——

General SMITH. The last 3 months, 94. Let me ask Mr. Jacobs if he can add to my figures. Are there any more comprehensive figures than that?

Mr. JACOBS. We had a loss of 150 to private industry in the last two quarters. The trend has been increasing. We would estimate that our losses over the last 12 months have been in excess of 300.

Representative PRICE. Do you find the loss to be principally in the group who are with you longer or for a shorter period of time?

General SMITH. I would say, sir, that they are in the central area largely. The men that we do recruit in our GS–5 grade and who are advanced to grade 7 after 6 months are young engineers that we are giving a good 2-year rotational training program. We hold them during that period on the whole. We are also holding the other extreme, the top men who have been with us a long time and who have a real investment in their civil service retirement. It is in the middle area, after a man has accumulated good experience in the Corps of Engineers and has become a real engineer on top of his degree, but sees the greener fields of higher pay in civilian industry, that they leave us.

I have some figures here which Mr. Jacobs, the Chief of Civilian Personnel, has just handed me. I find, for example, that 3- to 10-year period shows large losses, and under 1 year, surprisingly, shows large losses. So we do have a large turnover in that first year, people who quit after having been with us a short time. Then they stay, generally speaking, for a few years. Then between the third and tenth year we have heavy losses which fall off very markedly after the tenth year.

Representative DURHAM. One thing that you mention there interests me in regard to sending these boys from West Point to college for 9 months. Do you send them all to college?

General SMITH. By far the larger proportion, not all.

Representative DURHAM. In other words, you can't count on any this year from West Point, you are going to send them to school?

General SMITH. We send them out to troops, first, Mr. Durham. The first 2 years of their service, generally speaking, are with troops, to learn to be an officer and learn to be a leader and a commander of men, to learn the fundamentals of troop leadership. Then they get into technical schooling and construction work and various types of true engineering activity. It is true, though, that we do have a sizable number of our people out at school at all times.

Representative DURHAM. Don't they get all that instruction in West Point? You mean a man is there 4 years and doesn't learn how to handle troops?

General SMITH. Yes, sir; he learns much about handling of troops——

Representative DURHAM. That is what I thought.

General SMITH. But it requires an additional period actually in command of a platoon and of a company to develop the real qualities of command which a young officer should have. He learns the fundamentals and comes out of West Point a good basic leader. He has the potential built into him, but he does require the active troop command work to bring that to a head.

Representative DURHAM. If we are going to put him in a civilian school somewhere—of course you know the crowded conditions in engineering schools throughout the country, and one of the problems is that there are not enough engineering schools, either, to turn out these engineers. It looks as if we might try to do something about extending his service a couple of years and do it right there at West Point.

General SMITH. I would like to point out, Mr. Durham, that I am speaking of graduates of West Point who go into a technical branch, such as the Corps of Engineers, and then are sent to school. Perhaps I misunderstood your question before. The majority of the graduates of West Point do not go on to civilian school. The majority of the number who come into engineering do go on to civilian schools, but that is only a small percentage of the total graduates of West Point.

Representative DURHAM. I was speaking primarily of the engineers, of course.

Representative PRICE. General, I notice that you state that four-fifths of your officer personnel are Reserve officers. Do you have a large number of requests for resignations each year among these Reserves who are talented engineers who might have opportunities in private industry?

General SMITH. The largest share of that is from the young officer upon completion of the 2 years he has to stay in. He could elect to stay longer. He does not. Ninety percent of those who complete the 2 years do then leave the service. Of those who have stayed on a longer period of time, who have been in the Army since World War II days, not a very large percentage are leaving the service now, sir.

Representative DURHAM. Could you give us the percentage of the West Point graduate engineers who resigned from service last year? I mean the 2-year boys.

General SMITH. Yes, sir. They are not permitted to resign until they have completed 3 years' service.

Representative DURHAM. That is what I thought.

General SMITH. The average Corps of Engineer officer who is resigning now, the average number after 3 years' service, is running in the area of 16 percent of each class. I do not have the exact figures with me, and it has varied from 14 to 20 percent. I believe it is running now around 16 percent. I would like the privilege of checking those figures and correcting them if I am slightly wrong there.

Representative PRICE. Is there anything further, Mr. Durham?

General, I don't think that I have anything further to query you about. You have pretty well stated the problem and have put forth some suggestions that I am sure the committee will want to study. Some members have entertained thoughts along the line that you suggest of a scholarship idea similar to the Holloway plan. I know these matters will be given attention by this committee. We are not working on any particular legislation. We merely wish to point out to the Congress and to the people of the country the fact that the problem does exist in the shortage of scientific and engineering manpower in the United States.

Almost every statement we have had so far from every witness has further confirmed our belief that this is a serious matter and certainly we should seek some solution to the problem. We see the immediate problem and we see the long-range problem. I am glad to have the definite recommendations from almost every witness who has appeared. Almost everybody has an idea of what to do about it, which is an unusual situation. Usually most people come in and state the problem without offering at least what they believe to be the solution. Almost every witness we have had has some idea of what might be done to meet the problem. We certainly appreciate the cooperation and the time you have given to make this appearance here.

General SMITH. Mr. Chairman, I certainly appreciate the courtesy that you have given us. The opportunity to testify has been a real courtesy in itself, and we appreciate this chance to come here and give you our very honest views.

I would like to add, Mr. Price, that if as your committee continues its deliberations and when General Sturgis returns to duty you have any occasion to call on us for further information, General Sturgis personally would be only too glad to come over and give you his further views and answer any specific questions you might have. He has a lifetime of experience in this field and very strong feelings about the problems on which you are working and would be very pleased to have the opportunity of coming over any time you may have any reason for further call on the Chief of Engineers.

Representative PRICE. Thank you, General.

General, you and many other witnesses have mentioned the two speeches made before the Thomas Alva Edison Foundation Institute, the one by Admiral Rickover and one by Admiral Strauss. I ask unanimous consent both of these speeches be included in the record.

(The speeches referred to follow:)

FREEDOM'S NEED FOR THE TRAINED MAN

By Lewis L. Strauss, Chairman, United States Atomic Energy Commission

If there is to be another war among the great nations of the world before the human race discovers a method of abolishing recourse to combat, that war

may be survived by the country with the greatest stockpile of nuclear weapons and instruments of their delivery. But such a war will almost certainly be lost by the country with the fewest resources in trained manpower.

This is a conclusion which has been reinforced for me by experiences during the past 15 years, first with the research activities of the Navy and later with the Atomic Energy Commission. In the latter area, there are three components necessary to success in meeting our established objectives. These are, first, the elemental raw material, second, the required funds, and third, human skill and intelligence.

Early in the work of the Commission, it looked as though the raw material would be a limiting factor. Most of our uranium was mined in Africa. By setting incentive prices which vigorously stimulated exploration and prospecting all over the world (and especially within our own borders), we have stepped up the production of this vital material to a point literally undreamed of 10 years ago.

The second requirement, money, has never been denied to the enterprise by the Congress. The appropriation of money is an expression of the degree of the concern and interest of the American people, their concern with their security and defense, and their interest in supporting discovery, a national characteristic since the earliest settlers reached our shores.

The third and indispensable component of success obviously is gray matter. Here, also, we have been fortunate, until now. But while we can look ahead and see no indications of dearth in raw material or means, the prospect for trained minds is a very different and gloomy one. Deposits of uranium can be located, opened, mined and converted into metal in a very short time. Appropriations can be voted quickly whenever the Congress decides them warranted. But men and women cannot be qualified in disciplines so exacting as modern science without a dedicatory period, an apprenticeship, of years.

If you are concerned with the reasons for apprehension that this third component of progress and defense is in any way endangered, and I believe that it is, then this occasion associated with the memory of Thomas Alva Edison, the possessor of a self-trained mind, and therefore one of the great and unique exceptions, seems an appropriate opportunity to discuss the facts.

The recent Conference in Geneva on the Peaceful Uses of Atomic Energy produced a number of notable results, which was perhaps to be expected since it was the greatest scientific gathering ever convened. Some of these results already are evident; others will materialize as new inventions and refinements in many facets of the nuclear art bear fruit from the cross-fertilization of Geneva.

SCIENCE IN U. S. S. R.

An immediate result was that we learned much about the quality of Soviet science, in terms of both the individual and the products of his talents. And what we learned was sufficient to shatter any complacency we may have enjoyed in regard to our own imagination and ability. Too many of us have fallen into the easy attitude of assuming that the Russians, because of what we have observed of the sinister purposes and slave methods of their political system and the compartmentalization of their research, could never match us in scientific initiative and progress.

This was dangerous self-delusion. Actually, the emphasis which the Soviets are placing on science and particularly on the training of new young scientists and engineers, presents a real and growing challenge to us. and to the free world.

Today their technical schools and universities are turning out scientists and engineers who are well-trained and highly competent. Since Geneva we know this. The quality may differ from field to field, but generally speaking, their first-rank men appear to be as good as our own.

The Soviet challenge is not one of technological quality so much as of numbers. It is evident that we are rapidly falling behind Soviet Russia in the training of engineers and scientists. The level of our reservoir of trained brainpower is dropping, in relation to the demand. They, on the other hand, are striving to fill theirs to capacity as rapidly as they can.

The facts and figures speak for themselves and they are not pleasant facts and figures. I should say here that their absolute accuracy cannot be assured, which is the case with most data from the dark side of the Iron Curtain, but they

deserve and demand the prompt attention of everyone who is interested in the continuation of our prosperity and in preserving our security and in maintaining peace.

We do know with certainty that we are turning out less than one-half the number of scientists and engineers we require, an alarming statistic by itself. You may have noticed that, each Sunday, from 6 to 10 pages of the metropolitan press are filled with advertisements attempting to enlist scientists and engineers to fill waiting jobs. These advertisers are for the most part the industries to which we look for the tools and weapons of our defense.

Inevitably our shortage of scientific manpower will become worse before we can do anything to correct it. This is an inescapable fact.

OUR PRECARIOUS ADVANTAGE

At present, we are about even with, or perhaps slightly ahead of the Soviets in numbers of trained scientists and engineers, about 1 million in each country and, in Russia's case, for an industrial establishment far smaller than ours. At the moment we probably have more topnotch men than they have, since about half of those presently at work in the Soviet Union were trained under inferior prewar standards. However, last year Russia is estimated to have produced as many doctors of science as we did.

Russia has some 520,000 graduate engineers, and we may be sure that substantially all of them are engaged upon the work for which they were schooled. We presently have a somewhat larger number of graduates, but this is more than offset by the fact that only 65 percent of our engineers are actually working at their professions. A third of them have gone into executive jobs, or have wandered off into sales promotion, finance and other lines of work.

We require from 45,000 to 50,000 new trained engineers every year. We are getting half that number. Last June's crop was around 23,000. Russia, at the same time, produced 53,000 new engineers and is expected to substantially increase that number next year and each year thereafter. She is graduating 120,000 new scientists and engineers of all types this year, which compares with our total of 70,000 graduates.

Between 1950 and 1960, which may be the most critical decade of our national existence, Russia is expected to produce 1,200,000 trained engineers and scientists, against our 900,000.

In the face of figures such as these, we cannot take refuge in thinking that this Soviet crop is of an inferior, mass-production grade, or that they cannot maintain their high rate of output.

COMPARATIVE EMPHASIS

The fact is that the sciences have an overriding priority in Russian education. More than half of all Russian university graduates are in the science-mathematics fields; only one-fifth of our graduates are in those fields. Russian Ph. D.'s, or the equivalent, are 3 to 1 in favor of science and engineering; in the United States the ratio is just the reverse, nearly three doctorates in the humanities for every one in science and mathematics.

Where is the answer to this challenge to be found? Where are we to obtain the trained men to replace the present personnel in our laboratories and science faculties and industries as they retire or pass away, and to fill the expanding demand in every field for more and more scientifically trained people? The trouble does not rest, I think, at the end of the line of training, that is to say in our colleges and universities. They cannot create the candidates for these posts without the human material to start with. The difficulty lies more deeply in our educational system. Our graduate institutions cannot supply the scientists and engineers we need if students do not come to them, ambitious to be scientists and engineers and possessed of adequate high school preparation for such careers. The decisions that produce our skilled scientists and technicians are made, in the main, before they arrive on the college campuses.

LOOKING AHEAD

Only about 16 percent of the high school graduates entering college last year enrolled in engineering courses, or about 66,000 of them. That is not an entirely gloomy statistic, because the ratio has been going up, slowly but steadily, since 1950 and is expected to hold fairly steady around that 16 percent for several

years to come. However, this must not be construed to mean that we will have 66,000 or more graduate engineers each year. Attrition, on the basis of our experience, will take a heavy toll. More than half of these 66,000 young hopefuls will flunk out along the way, or switch to other, easier courses. Ask the deans of our engineering schools for the reason and a composite of their answer is—"poor high school preparation in science and mathematics."

Our high school systems, or, to be more accurate, you and I, are failing in our obligation to our national welfare and security. We fail when we squander the most valuable of our natural resources. Our youth is not being exposed to the excitement and challenges of science. We are not equipping the growing generation to protect or even to fully enjoy their modern heritage.

Large numbers of our high school students have no opportunity to discover whether science and engineering appeal to them, because preparatory courses are not available, or, when such courses do exist, they often are taught by instructors who double in science, but whose interests lie in other subjects.

QUALITY OF INSTRUCTION

A recent survey indicates that from 250,000 to 400,000 high school students in our country presently are learning mathematics from teachers not trained to teach it, and the same situation prevails in science teaching. Government figures show that part-time science teachers in our schools outnumber full-time science teachers.

Since there are not enough trained teachers to go around, the alternative becomes one of using unqualified teachers, or abandoning those courses. In an appalling percentage of instances, as I shall cite in a moment, the courses have been abandoned.

The problem becomes a chain reaction in reverse, because fewer and fewer high school courses in math and science mean fewer and fewer college students of science and engineering, and fewer graduates. And fewer graduates mean fewer persons with either the inclinations or equipment to teach science and mathematics in the high schools. Thus, the teacher shortage grows progressively worse.

A graduate scientist or engineer cannot reasonably be expected to choose a teaching career at a salary so low that he may be compelled to take an afterhours job, often of a menial nature, to even make ends meet, when he has the option of a number of better paying jobs elsewhere. This has made it easy for industry to attract the people who would be science teachers, and thus the seed-corn is eaten up with no concern for the future.

Our high school enrollments are growing but there are fewer college graduates to teach them. The number of qualified teachers of science and mathematics has fallen off about 53 percent in the past 5 years while the high school student body has increased 16 percent and continues to go up.

SITUATION MAY WELL GROW WORSE

The figure which I have cited of a 53 percent drop in the number of qualified math and science teachers, in reality, is a sugar-coated one, because not more than half of the men and women who leave college qualified to teach those subjects ever find their way into a high school classroom. For example, of the 1954 college graduates qualified to teach chemistry, about 36 percent actually did so. What happened to the others? The explanation is the familiar one—better paying jobs in other lines of work.

One needs no more than these few statistics to see that our supply of scientific and technical manpower is withering at its source—in the high schools—for want of nourishment, while the Soviets assiduously cultivate ever larger numbers at that same level.

In Russian high schools, of the study courses which every student must take, 40 percent are in science and mathematics. I am told, furthermore, that young Ivan is made to work much harder than our Johnny; he goes to school 6 days a week and by the time he completes high school he has had 6 years of biology, 5 years of physics, 4 years of chemistry and 4 years of mathematics, including trigonometry. I can learn of no public high school in our country where a student obtains so thorough a preparation in science and mathematics, even if he seeks it—even if he should be a potential Einstein, Edison, Fermi, or Bell.

OUR CHANGED CURRICULUM

If this were not sad enough, more than half (53 percent) of our high schools do not teach physics at all. In half our schools students simply have no access to this subject which is so important to an understanding of the technological world in which they will spend their lives.

Half of our high schools do not teach chemistry.

Two generations ago, in 1890, 1 in every 5 high-school students studied physics. Today it is only 1 out of every 22. More than half of all students back in those days studied algebra; now it is less than one-fourth. The study of chemistry has fallen off 30 percent. These are the statistics of the United States in the era of technology.

Let us look briefly at the situation that prevails in those high schools still struggling to maintain science and math courses.

A survey of 30 States showed that about 1,800 new mathematics teachers were urgently needed, but 700 of the positions had to be filled with unqualified persons, including instructors in such unrelated subjects as music, home economics, and physical culture.

I sincerely hope that none of my remarks will be regarded by anyone as reflecting upon our high-school teachers. They are devoted, underpaid, and self-sacrificing people and we have too long taken advantage of their devotion. If the teacher of music, or the high-school athletic instructor, is required to teach chemistry or mathematics because no qualified instructor can be obtained, the blame should attach to us, for allowing our educational system to fall into such a regrettable state.

IMITATION NO ANSWER

Also, I have dwelt on the contrasts in our educational program and its result with that of Soviet Russia, but not in any sense to suggest that what the Soviets are doing contains a solution to our problem. Their system of regimentation and even enslavement of the individual as a pawn of the state is repugnant to us. Our solution will have to be an American solution, consonant with our traditions of freedom and the dignity of the individual.

First of all, we must in some manner insure that those students with demonstrated aptitudes receive the inspiration they deserve. This is a challenge to parents, educators, industry, professional societies and for Government at the Federal, States, and local levels. It should be a matter of national remorse that less than half of our brightest high-school students—those in the top 20 percent of their classes—go on to college, and only 2 percent of those judged capable of earning doctor of philosophy degrees do so. We go to great lengths to conserve our forests and wildlife and waste the most valuable asset of all.

Clearly one corrective is money. With adequate funds teachers can be fairly compensated and their numbers thus increased as they become trained and available. But where are the funds to come from? The costs of our school system are only second to those of our Defense Establishment. It is, therefore, beyond expectation that private or institutional philanthropy could step into the breach.

FEDERAL ACTION: PRO AND CON

Does this mean the Federal Government must intervene? Many think so They hold that a crisis is in effect upon us, that it is vital to our defense to have trained men not only at the controls of our complex instruments of warning and war, but especially in the laboratories whence these devices are to come, and that since these men must as a prerequisite come out of our educational system, the system itself must be federally supported if support is wanting. This is a hard argument to combat. But the consequences of Federal support are unacceptable to those of us who would like to see our educational system continue free from dependence upon Federal subsidy and from the interference and perhaps control which could follow the acceptance of such subsidy.

Many of us should be thinking of what might be done at once to begin to solve our problem. I have two proposals to advance—one immediate, the other a longer range action. Both are based upon the proposition that the public generally is unaware of the situation we face and will act intelligently, promptly, and generously when it learns the facts.

For the short range I would propose that industry and the professional societies undertake through ther organized bodies to popularize a plan whereby every engineer and scientist in the country would volunteer to conduct classes in physics, chemistry, and mathematics in our secondary schools, for a few but

certain number of hours each month during the school year. If this procedure were to be generally followed, the number of science-qualified entrants to our college system would make an appreciable change in the alarming figures now confronting us.

COLLEGE ADMISSION REQUIREMENTS

My second thought deals with the longer range problem, would be more difficult to organize, but might solve the problem once and for all. It is simply that the colleges should recognize the gravity of the threat we face and make a certain minimum of credits in physics and chemistry a requirement for enrollment. For instance, if such great associations as the American Council on Education, the Association of American Colleges, the Association of American Universities, and the Association of Land Grant Colleges and Universities were to consider and act favorably upon some such a proposition, we would see a great change in the curricula of the secondary schools. If their graduates had to have science to qualify for college admission, the local communities would insist that their school boards furnish it and if that meant paying a proper salary to science teachers to secure them, the means would be found. It is easy to demonstrate also that the costs at the local level will be less than if the funds have to be collected through Federal taxation and then fed back to the localities with all the cost of collection and Federal administration added.

These several suggestions will surely be inferior to others that will come from educators who are more conversant with the difficulties than a layman can possibly be. I can only hope that prompt thinking and effective action will be stimulated by what is being said on this subject by Dr. Alan T. Waterman, Mr. Allen Dulles, and others who have been deeply concerned by the consequences of the situation in which we suddenly find ourselves.

WHAT IS AT STAKE?

The extent to which science has become a major factor in our living, our environment, and our fate, is something now apparent to all who will examine the facts. Our position of eminence and influence in the world has been due to the prudent and vigorous applications of technology to the development of our resources and our industrial potential. It has been built on an educational system conducted by independent communities and, until recently, healthily concerned with the cultivation of the natural sciences and mathematics along with the humanities.

If we value these possessions which have made for our eminence and influence, we must be prepared to defend them. Our greatest possession—freedom—is itself partly the product of science, since it was technology which made slavery unprofitable, and under freedom and only under freedom all our other treasures flourish.

It is a paradox that we should find ourselves at this point in history suddenly poorer in the very means by which our greatness was achieved.

This is the cold war of the classrooms.

In 5 years our lead in the training of scientists and engineers may be wiped out, and in 10 years we could be hopelessly outstripped. Unless immediate steps are taken to correct it, a situation, already dangerous, within less than a decade could become disastrous.

Engineering and Scientific Education

(By Rear Adm. Hyman G. Rickover, USN, Chief, Naval Reactors Branch, Division of Reactor Development, U. S. Atomic Energy Commission, Assistant Chief of the Bureau of Ships for Nuclear Propulsion, and Head of the Atomic-Powered Submarine Projects, the *Nautilus* and the *Seawolf*)

For the last 8 years my work has been in the field of nuclear power. In dealing with the problems involved in developing this new source of energy, I have found them to be but one facet of a much larger problem—how to provide the trained men and women to maintain the momentum of our rapidly expanding technical civilization. You are all aware that our explosive population growth has placed a tremendous strain on the resources—human and material—of our educational institutions. There are just not enough good teachers and schoolrooms to give each child the opportunity to develop his capabilities to the fullest.

I consider the present crisis in education as grave a problem as any that faces our country today. Unless it is dealt with promptly and effectively the machinery which sustains our level of material prosperity and political power will begin to slow down and we will be in danger of losing the cold war by default. Let me illustrate this with a few figures:

First, the United States has doubled its population in the past 50 years and is expected to double it again by the end of the century.

Second, with only 7 percent of the world's population and 8 percent of the land area, the United States is today responsible for more than half the world's production.

Third, to maintain our relative position in the world economy and to preserve our high standard of living, American industry must—10 years from now—produce 40 percent more than it does today.

The use of electric power, for example, is expected to quadruple in the next 25 years. Or take minerals and most mineral fuels: The United States has used up more of these in the last 30 years than the entire world did in all of history before 1914. A similar growth in consumption in the next 30 years cannot occur unless we make profound changes in technology.

EXPERIMENT OR PERISH

Our accelerated increase in production over the past century has been due to the efforts of but a small number of companies. Only 1 percent of all the businesses in existence 100 years ago are still alive today. And in a recent study by the Brookings Institution it was shown that only 38 of the 100 largest industrial companies existing in 1909 are still in business today. The companies which survived are those which have been willing to experiment, to take risks, to innovate, to break precedent. Their managements have anticipated and helped to bring about the very changes which caused their less astute or less courageous competitors to slip back. These companies hold their place in a world of change. The top is a slippery place.

The same holds true for nations. Like industrial organizations, they will decline if they are not continually alert to the needs of the future. The law of life for industrial organizations and for nations is the same—adapt or perish. The industrial, and hence the political, power of nations is dependent in large part on their scientific and engineering professions, and these in turn depend on a continuous inflow of capable and well-trained individuals. In other words, a nation progresses or falls back in the race for survival to the degree that it succeeds or fails to afford each individual citizen the maximum opportunity for education and training.

An essential function of leadership, in the government of nations as in the management of industries, is to plan for the future. What we do today was largely determined for us by the vision and action of those who preceded us. Likewise tomorrow's events will depend on what we plan and do today—on the wisdom we use in planning for the future. Perhaps the most insidious weakness a nation can have is the belief, fostered by propaganda of one kind or another, that it can do everything better than other people. We in this country are subjected to this kind of propaganda in various media—such as the slick advertisements of magazines—week upon week, month upon month. We overlook what we do not hear much about, especially if it is unpleasant.

UNPLEASANT FACTS

One of the unpleasant facts which has but recently been mentioned is that in the field of scientific and engineering education our main competitor, Russia, is speedily passing us. According to the best estimates, the United States now has about 800,000 engineers and scientists; Russia, 650,000. Disturbing as this is, it is insignificant as against the rate with which she is increasing her engineering and scientific talent compared with us. In 1954 she graduated more than 50,000 engineers and scientists; we graduated 23,000. Mr. Allen Dulles, the Director of our Central Intelligence Agency, has stated that between 1950 and 1960 Soviet Russia will have graduated 1,200,000 scientists and engineers, compared with 900,000 in the United States in our present program. Thus by 1960 it is estimated she will have more engineers and scientists than we; moreover, the rate of attrition in Russia is lower than ours because of lower age.

Some may argue that Russian engineers are not technically as well trained as ours. This is not the case. It is true that they are trained in engineering exclu-

sively and at the cost of their general education. Further, their engineering training is confined to narrow specializations. This is so because the Soviet educational philosophy is based on the premise that the purpose of education is to train the individual for the particular purpose the state requires.

You know what kind of a job the Russians have done on jet engines, radar, long-range bombers, and atomic weapons. Their industrial production has quadrupled in the last 15 years.

THE CLEAR TRENDS

The Russian approach to education is a total approach. They are educating as many women as men, and women constitute one-half of the total in the professions. In contrast, in the United States this is but a fraction of 1 percent. Can we continue to neglect so large a potential of trained personnel?

While our mass-production system will permit us, for the time being, to build more things faster than Russia, their engineers may soon, by their very numbers, invent better machines. In rate of progress they are, in fact, already ahead of us. We must not take for granted our present technological leadership.

There are some who believe that the United States is not even graduating enough trained people merely to sustain our present rate of technical expansion beyond the year 1970. What is certain is that unless the number of our scientists and engineers increases at an accelerated rate our economy will be in serious trouble for lack of technological nourishment, because our pool of graduate engineers is the source from which arise nearly all our technological advances from jet engines and nylon, to earth satellites, atomic power, and intercontinental missiles.

In light of these facts, the present Soviet peace offensive makes a great deal of sense to the Russians. Recently Mr. Khrushchev said: "We don't have to fight. Let us have peaceful competition and we will show you where the truth lies. * * * Victory is ours."

Can we in the United States permit this challenge to stand?

QUALITY IMPERATIVE

America's present educational crisis is not only one of quantity—i. e., not enough engineers and scientists being graduated each year—but also one of quality. And this is a serious matter, for in the contest with Russia we must depend on greater human quality, since we cannot match her manpower in numbers.

Our primary and secondary schools have recently come in for much criticism for not doing a good job. Actually, the average high school graduate of today is better trained than the one of 75 years ago—which should not surprise us since today's school year is twice as long as that of 1870; the proportion of teachers to pupils is greater; and—even taking into account the changed value of the dollar—we spend 9 times as much per pupil today as we did in 1870. We have thus a situation where the child goes to school twice as long, costs us 9 times as much to educate, but gets only a little better education than he was getting 85 years ago.

Unsatisfactory as this may be, the real issue is not whether the present-day pupil compares favorably with the pupil of 1870, but whether he is adequately trained for the demands of today's society. I submit that he is not.

I say this on the basis of study, intuition, and the experience I have gained from interviewing more than 1,000 college graduates over the past 10 years.

My experience in selecting people may have some relevance for other engineers because the design and development of nuclear powerplants is extremely difficult. It encompasses the most advanced scientific and engineering concepts in physics, mathematics, chemistry, metallurgy, electrical engineering, electronics, and mechanical engineering. The problems we face in nuclear powerplants are indicative of what all branches of engineering will soon have to face.

The single most important thing I have learned from these interviews is that all but a small number of the young college graduates lack proper motivation. Some of them consider their degree merely as a ticket to a job, and a pass for security. They use the college as a "service station."

This desire for security in terms of money, rather than in opportunity for self-improvement, is hard to understand in a society where security is so readily available.

Another important point that has been made clear to me in interviewing young graduates is that they know many facts—but they have not learned many prin-

ciples. Principles are more important than facts and far more difficult to master. But once a principle is learned, it becomes a part of one, and is never lost. The facts we learn are soon forgotten and their meaning changes with time. A trained man knows how to answer questions. An educated man knows what questions are worth asking.

My concept of a good engineering course is one in which the student learns the principles of mathematics, of physics, of mechanics, of electricity, of metallurgy, and of chemistry. A thorough understanding of these leads easily to handling the facts associated with them.

I do not believe that "practical stuff" should be or can be properly taught in a university. The reason is easy to see. Nearly all college textbooks are several years behind current industrial practice. Furthermore, they are written by men who do not have the latest "practical" information, so that the texts are obsolete even while they are being written.

The employer who wants a "practical" engineering graduate is simply hiring a man who knows how to make the same mistakes that have been made in his plant for the past 10 to 15 years.

WHOSE RESPONSIBILITY?

The failure in education is not the fault of the educators alone. It is the fault of all of us in not recognizing the impact of the 20th century scientific revolution and taking the necessary measures in time.

I have tried to give you my view of some of the problems that face us in engineering education. What can we do about them?

First, we must see to it that every young man and woman who is qualified obtains a college education. Today less than half of those capable of acquiring a college degree enter college. Sixty percent of the best students graduating from high school do not go to college. This is a tremendous loss of talent amounting to 250,000 students each year. And nearly half of all those who do start college do not graduate. For every high-school graduate who eventually earns a doctoral degree there are 25 others who have the intellectual ability to achieve that degree, but do not. We simply cannot afford a waste such as this.

Second, we must increase the funds for education. The United States is spending about 2½ percent of the national income on education. In contrast we spend more than 4 percent on recreation. We spend more money for comic books than for all textbooks used in our elementary and high schools. In 1951 the amount spent for advertising was $199 for every family in the United States, but the amount spent for primary and secondary education was $152 per household. This means that our national outlay for the education of citizens was substantially less than our expenditures for the education of consumers.

It may amuse you to know that in a recent year the United States home-permanent-wave industry budgeted for research into ways of improving the looks of human hair a sum amounting to 2 cents per United States (female) capita. The whole Nation meanwhile was spending only 3 cents per capita for research into the distressing things that go on inside the human head.

HOW MUCH ARE TEACHERS WORTH?

Third, from what I read in the papers we seem to be more concerned with expenditures for school buildings than for spending money to obtain better teachers. Schools can be constructed in 2 years or less, but it takes 4 years to train an elementary- or high-school teacher, and 7 to 8 years to train a college professor. Our school buildings may be the best in the world, but can we say the same of our teachers? I do not mean to imply that we should not have the best school buildings, but perhaps our children would be better off with fewer buildings but with the best teachers it is possible to obtain. We plan to spend $25 billion in the next 10 years on school buildings. What amount are we prepared to spend for assuring better teachers for these schools?

The real question is, "Can we afford not to spend enough for such assurance?"

This leads me to the question of the salaries we pay teachers. Compared to other professions there has been a considerable drop in their purchasing power, particularly for those at the highest professional levels. The deterioration at the top is so great that it has affected the attractiveness of the academic career as compared to other professions.

In any profession, and particularly in the teaching profession, there are dedicated people who will work under adverse conditions and at low pay. But we

must not delude ourselves that the answer to our dilemma lies solely in dedicated people. There will never be enough of these. We are not entitled to educate our children on the philanthropy of our teachers. Whether we like it or not, in the culture which exists in the United States today the desirability of a given occupation is measured largely in terms of salary. As a rule the better people are attracted to the higher paying professions. This explains why the ablest young men and women are turning away from teaching even though numerous scholarships and fellowships are available. No such recruitment problem exists, for example, in medicine or in law. These have no lack of applicants; in fact many are turned away.

When the income of teachers rises to the point where it competes with other professions, it will attract the right kind of people.

Therefore, I submit that an immediate step in solving our educational problem is to increase salaries drastically. It little matters that some teachers will be overpaid. The low salaries paid for the past 50 years have served to attract to the teaching profession many who are not really qualified. It will profit us very little to spend millions of dollars on scholarships and then place the students under incompetent teachers. Increasing salaries is the surest way to attract more competent men and women over the long run. Further, when salaries are increased it will be possible to base advancement on performance, and not on the basis of time served.

CURRENT ALTERNATIVES

Unless we quickly remedy the present treatment of our teaching and scholarly resources we will inevitably have morally and intellectually incompetent teaching staffs. Eventually the bright young man will sacrifice his desire to teach in favor of an adequate standard of comfort, decency, and security for his family. The movement away from teaching has actually begun and it looks as though it will continue at an increasingly rapid rate.

We all know of the nationwide shortage of elementary and high school teachers. What is not evident is the real meaning of this shortage, because very few classrooms are ever closed because a teacher is lost. What happens is that teaching standards are lowered or the class size is raised. Both of these accommodations are already taking place at a growing rate. When a teacher with the desired qualifications is not available, someone with lesser qualifications is hired. The teacher then becomes, in effect, a "baby sitter."

The result of this niggardly payment of our teachers—of those upon whom we depend to transmit our culture and our civilization—is to commit a fraud on our children. If the children were as astute as their elders supposedly are they would say: "I'm sorry, but I'm not ever going to be 10 years old again. Can't you afford to give me good teachers now?"

LENGTHEN SCHOOL YEAR

Another thing we can do is to increase the length of the school year. The present school year is based on the requirements of an agricultural economy where the children had to help on the farm. True, the actual number of days at school now averages about 180 as compared with 90 days about 80 years ago. But, as you well know from your own experience, and from what your children tell you, many of these 180 days are wasted. With the great and geometric advance in knowledge since the turn of the century, can we afford to have our children devote less than half their available days to elementary schooling? Students in Europe, including Russia, attend school 6 days a week instead of 5, and their vacation period is about two-thirds of ours.

There is no longer a sufficient number of years left during youth to develop properly educated men and women. And we cannot keep them in school too long after they reach the age of 22 or 23 because it is then time for them to face the problems of the world. So it is to the earlier years that we must look for added learning. This problem has become particularly acute due to universal military training.

Many of you occupy responsible positions in industry, and you know that the great increase in our productive capacity comes from the optimum use of people and facilities. Some of the problems of education, particularly those concerned with administration, are susceptible of solution by the same methods we use in industry. Industry cannot operate effectively on a 180-day year. Why should we think our schools can?

ciples. Principles are more important than facts and far more difficult to master. But once a principle is learned, it becomes a part of one, and is never lost. The facts we learn are soon forgotten and their meaning changes with time. A trained man knows how to answer questions. An educated man knows what questions are worth asking.

My concept of a good engineering course is one in which the student learns the principles of mathematics, of physics, of mechanics, of electricity, of metallurgy, and of chemistry. A thorough understanding of these leads easily to handling the facts associated with them.

I do not believe that "practical stuff" should be or can be properly taught in a university. The reason is easy to see. Nearly all college textbooks are several years behind current industrial practice. Furthermore, they are written by men who do not have the latest "practical" information, so that the texts are obsolete even while they are being written.

The employer who wants a "practical" engineering graduate is simply hiring a man who knows how to make the same mistakes that have been made in his plant for the past 10 to 15 years.

WHOSE RESPONSIBILITY?

The failure in education is not the fault of the educators alone. It is the fault of all of us in not recognizing the impact of the 20th century scientific revolution and taking the necessary measures in time.

I have tried to give you my view of some of the problems that face us in engineering education. What can we do about them?

First, we must see to it that every young man and woman who is qualified obtains a college education. Today less than half of those capable of acquiring a college degree enter college. Sixty percent of the best students graduating from high school do not go to college. This is a tremendous loss of talent amounting to 250,000 students each year. And nearly half of all those who do start college do not graduate. For every high-school graduate who eventually earns a doctoral degree there are 25 others who have the intellectual ability to achieve that degree, but do not. We simply cannot afford a waste such as this.

Second, we must increase the funds for education. The United States is spending about 2½ percent of the national income on education. In contrast we spend more than 4 percent on recreation. We spend more money for comic books than for all textbooks used in our elementary and high schools. In 1951 the amount spent for advertising was $199 for every family in the United States, but the amount spent for primary and secondary education was $152 per household. This means that our national outlay for the education of citizens was substantially less than our expenditures for the education of consumers.

It may amuse you to know that in a recent year the United States home-permanent-wave industry budgeted for research into ways of improving the looks of human hair a sum amounting to 2 cents per United States (female) capita. The whole Nation meanwhile was spending only 3 cents per capita for research into the distressing things that go on inside the human head.

HOW MUCH ARE TEACHERS WORTH?

Third, from what I read in the papers we seem to be more concerned with expenditures for school buildings than for spending money to obtain better teachers. Schools can be constructed in 2 years or less, but it takes 4 years to train an elementary- or high-school teacher, and 7 to 8 years to train a college professor. Our school buildings may be the best in the world, but can we say the same of our teachers? I do not mean to imply that we should not have the best school buildings, but perhaps our children would be better off with fewer buildings but with the best teachers it is possible to obtain. We plan to spend $25 billion in the next 10 years on school buildings. What amount are we prepared to spend for assuring better teachers for these schools?

The real question is, "Can we afford not to spend enough for such assurance?"

This leads me to the question of the salaries we pay teachers. Compared to other professions there has been a considerable drop in their purchasing power, particularly for those at the highest professional levels. The deterioration at the top is so great that it has affected the attractiveness of the academic career as compared to other professions.

In any profession, and particularly in the teaching profession, there are dedicated people who will work under adverse conditions and at low pay. But we

must not delude ourselves that the answer to our dilemma lies solely in dedicated people. There will never be enough of these. We are not entitled to educate our children on the philanthropy of our teachers. Whether we like it or not, in the culture which exists in the United States today the desirability of a given occupation is measured largely in terms of salary. As a rule the better people are attracted to the higher paying professions. This explains why the ablest young men and women are turning away from teaching even though numerous scholarships and fellowships are available. No such recruitment problem exists, for example, in medicine or in law. These have no lack of applicants; in fact many are turned away.

When the income of teachers rises to the point where it competes with other professions, it will attract the right kind of people.

Therefore, I submit that an immediate step in solving our educational problem is to increase salaries drastically. It little matters that some teachers will be overpaid. The low salaries paid for the past 50 years have served to attract to the teaching profession many who are not really qualified. It will profit us very little to spend millions of dollars on scholarships and then place the students under incompetent teachers. Increasing salaries is the surest way to attract more competent men and women over the long run. Further, when salaries are increased it will be possible to base advancement on performance, and not on the basis of time served.

CURRENT ALTERNATIVES

Unless we quickly remedy the present treatment of our teaching and scholarly resources we will inevitably have morally and intellectually incompetent teaching staffs. Eventually the bright young man will sacrifice his desire to teach in favor of an adequate standard of comfort, decency, and security for his family. The movement away from teaching has actually begun and it looks as though it will continue at an increasingly rapid rate.

We all know of the nationwide shortage of elementary and high school teachers. What is not evident is the real meaning of this shortage, because very few classrooms are ever closed because a teacher is lost. What happens is that teaching standards are lowered or the class size is raised. Both of these accommodations are already taking place at a growing rate. When a teacher with the desired qualifications is not available, someone with lesser qualifications is hired. The teacher then becomes, in effect, a "baby sitter."

The result of this niggardly payment of our teachers—of those upon whom we depend to transmit our culture and our civilization—is to commit a fraud on our children. If the children were as astute as their elders supposedly are they would say: "I'm sorry, but I'm not ever going to be 10 years old again. Can't you afford to give me good teachers now?"

LENGTHEN SCHOOL YEAR

Another thing we can do is to increase the length of the school year. The present school year is based on the requirements of an agricultural economy where the children had to help on the farm. True, the actual number of days at school now averages about 180 as compared with 90 days about 80 years ago. But, as you well know from your own experience, and from what your children tell you, many of these 180 days are wasted. With the great and geometric advance in knowledge since the turn of the century, can we afford to have our children devote less than half their available days to elementary schooling? Students in Europe, including Russia, attend school 6 days a week instead of 5, and their vacation period is about two-thirds of ours.

There is no longer a sufficient number of years left during youth to develop properly educated men and women. And we cannot keep them in school too long after they reach the age of 22 or 23 because it is then time for them to face the problems of the world. So it is to the earlier years that we must look for added learning. This problem has become particularly acute due to universal military training.

Many of you occupy responsible positions in industry, and you know that the great increase in our productive capacity comes from the optimum use of people and facilities. Some of the problems of education, particularly those concerned with administration, are susceptible of solution by the same methods we use in industry. Industry cannot operate effectively on a 180-day year. Why should we think our schools can?

Increasing the length of the school year, say to 210 days, would be the equivalent of making 2 additional years available before college.

If to these 2 years we added better teaching, better school administration, and better use of school facilities, it is quite possible that by the time a young man reached the age of 18 he could have completed the equivalent of the present day college course. This is not as farfetched as it may sound. Something close to this has been achieved in Europe.

PERMIT RAPID INDIVIDUAL ADVANCE

Another important thing to be done is to make it possible for every gifted student to advance as rapidly as he is able to. It may be impossible for us to compete with Russia in the number of trained people but we must excel in the quality of our trained people. To accomplish this requires a drastic change in our attitude toward our primary and secondary schools—particularly our high schools. Up to World War I the high school was intended as a preparatory school for those who desired to continue on to college or university. The courses were organized on this basis and they did a pretty good job, considering the cultural and scientific climate of the time.

But the high school of today is no longer a place whose primary purpose is to prepare students for college. Instead, its purpose has proliferated into providing educational, occupational, civic, and cultural training for every child.

In this time of acute teacher shortage in our schools we might well consider relieving them of the problems which could just as well be taken care of in the home or by other activities. Under pressure from various groups, courses are being given whose educational value is questionable. Nearly half of our high schools offer little or no instruction in physics, chemistry, or in mathematics beyond introductory algebra. The percentage of high school pupils who today study scientific subjects is indicative of this:

	1900	1950
Physics	23	4
Chemistry	10	7
Algebra	52	27
Geometry	27	13

The high schools have been required to arrange the necessary curriculum to take care of the average boy or girl. For many children the school makes up for what they cannot obtain at home; and, in some cases, it takes the place of the home. The ones who suffer are the gifted children. Some parents, those who can afford to, send their children to private schools. Whether or not these are really better than our public schools is a moot question. Certainly it is not altogether desirable to have children, during their impressionable years, associate only with those who have the same economic background.

TWO KINDS OF SCHOOLS

A partial solution to the high school problem lies in setting up two different kinds of schools, one having higher standards than the other. There can be no valid objection to this because boys and girls with the necessary ability could go to the more difficult school. True democracy does not require of us that we hold back the qualified; it does require that we give each individual the opportunity to develop his talents to the fullest.

There is, however, a current of educational thought which is opposed to special treatment of gifted children. It is claimed that there are too many difficulties and injustices involved in recognizing ability at an early age, so that children of all abilities must be educated in a common manner. It is also claimed that educational grouping of this sort leads to or accentuates social stratification, and is, therefore, undemocratic.

Neither of these arguments will bear critical examination. If it is considered democratic to give special care to our retarded children, as we should and must, why should it not likewise be considered democratic to help our brightest children. There are many thing which are pure gifts and which we cannot acquire even by the greatest application: They are endowments granted to us by God. Among these gifts are creative artistic talents, profound sensitivity to art, music or lierature, philosophical power, and scientific or engineering intuition.

Every outstanding scientist or engineer is in his own way an artist. That is why he is able to reach out into the unknown and grasp a new truth which remains invisible to others.

This is the reason we must seek out and cultivate our gifted children, for it is from their ranks that creative ideas will come.

I have spoken of these major methods by which our educational potential can be improved: Increasing the length of the school year together with better school administration; making sure that gifted children are afforded every opportunity; and obtaining enough good teachers.

SCALE OF DEMANDS

Here are the unprecedented educational problems we now face: Elementary school enrollment has risen from 20 million in the 1940's to 29 million today, and is expected to reach 34 million in 1960. High school enrollment will increase from 7 million today to about 12 million in 15 years. But the severest impact will be felt by the colleges and universities where the attendance will increase from about 2½ million today to between 5 and 7 million within the next 10 to 15 years.

To maintain the present pupil-teacher ratio the elementary and high schools will have to enlarge their teaching staffs by 500,000 in the next 10 years; this is a greater increase than took place in the previous 35 years. But to achieve a net increase of 500,000, three times that many will have to be recruited to take care of those who leave to get married, to take other jobs, or to retire. And the colleges and universities will have to add more teachers in the next 15 years than they have in all their previous history.

But faced with this formidable and unprecedented situation, we start with a present shortage of 140,000 qualified teachers. If the Nation's schools are to be adequately staffed during the next 10 years, more than half of the college graduates during that period will have to enter the teaching profession. But at present only one-fifth of the college graduates become teachers.

PUBLIC AND PRIVATE EFFORTS

Our difficulty arises from the fact that we are not living in a static society, nor do we have a static population. We are faced with a national problem of the first magnitude and a major and overriding effort by all of us is necessary—the Federal Government, the State and city governments, the schools, industry, and other private organizations. Because we have not been mindful of this situation does not mean that others have been equally unmindful. The meaning of what the Russians have been doing in education now becomes plain.

A partial solution and one which could be immediately effective is to enlist the aid of industry. Why cannot the scientists and the engineers from industry be given sabbatical leave to teach in our schools? The very shortage of college graduates and many of our educational problems have been created by the vastly increased requirements of industry. In 1900 the ratio of engineers to other workers was 1 in 300; today it is 1 in 60—and in highly advanced industries it has already reached the figure of 1 for about every 20 workers.

Industry is today short more than 40,000 engineers and will require a minimum input of 30,000 for many years to come. The only serious attempt made by industry to solve this problem has been to offer considerably higher salaries to young college graduates. This has resulted in an unhealthy situation where the small number of graduates are being sought after by many organizations. Recently, at 1 college, the same 200 members of the graduating class were interviewed by representatives of nearly 500 companies. This is not recruitment; it is inflation. We have learned in the case of goods that inflation can only be solved by greater production; this is true of college graduates as well. There is danger to the young graduates in being sought after so avidly. Success is too easily achieved, and he gains it so quickly and so easily that he has had no time to learn the humility to handle success, or even to realize that he will need humility.

It is not farfetched to expect industry to help carry this social obligation. In present-day America the business corporation is not a business device alone—it has become a social institution and has acquired the obligations inherent in this concept.

We have always recognized a duality in our schools: Federal and local support; public and private support. Industrial support of schools fits into this duality.

It has also been characteristic of our people that when a social need arose which Government was not able to take care of, groups of citizens have joined together to help.

SPECIFIC RECOMMENDATIONS

Specifically, I suggest that, at their own expense, industrial organizations make available their scientists and engineers for 1-year periods to teach in our high schools, colleges, and universities. The cost of this will be more than repaid by the larger number and better trained students who will soon be available.

Another thing industry can do is to help finance education. This has already been started by some corporations in providing scholarships and other aid. I suggest that financial contributions to education rather than scholarships be made, but on a considerably larger scale than is presently the case, perhaps as a percentage of gross sales. These funds might be assigned for distribution to central groups of men not associated directly with industry or with the schools. This will eliminate any possibility of industry being accused of influencing education or the schools of being self-seeking.

The use of manpower and funds by industry in this manner could be considered as a legitimate operating expense required for the future good of the business.

Similar contributions by labor unions would also be appropriate.

There are a number of aspects connected with this proposal which I would like to discuss at greater length, but which time does not permit. There is the possibility of using the funds so contributed for the establishing, staffing, and operating of new schools. There is also the possibility that scientists and engineers of each community, as part of a definite company plan, could act as counselors for one or more high-school students, devoting a part of their time to helping them to become interested and proficient in scientific and engineering subjects. They could also take over the leadership of the various after-school clubs in science, radio, mathematics, etc., thus relieving the teachers of this duty.

THE CHOICE NOW

The United States, if it is to succeed in its role of world leadership, must produce citizens who have the wisdom, the vision, and the knowledge to grapple successfully with world problems; citizens who can see critically through conventional values and who are able to subject to principle and to reason all claims to power.

In the conditions of modern life the rule is absolute, the race which does not value trained intelligence is lost. It will matter little what other excellences our educational institutions possess if they neglect to recognize and to foster high ability wherever it is found.

The task of insuring that every youth in our land is helped to his highest intellectual growth is a formidable one. This task arises not alone from the military situation posed by Russia, but also from the realities of the rapidly spiraling scientific revolution. We are faced with a fateful challenge. The way we, today, meet it, will determine the future of our country. We must not let it be said by future generations that we used our intellectual and moral capital without replacing it.

Only by an educational system strengthened, not only in its members and its organization, but in its sense of purpose can we hope to meet the obligations which today's events place upon us. And only if we meet them can we create in our society the kind of leadership without which we cannot hope to meet the responsibilities and the possibilities that our time has opened before us.

Representative PRICE. A statement from Mr. John Lester Buford, president of the National Education Association, and an article by Prof. Harry Ransom, of Harvard University, also a statement of policy by the American Chemical Society on matters relating to education will be made a part of the record at this point.

(The documents referred to follow:)

NATIONAL EDUCATION ASSOCIATION OF THE UNITED STATES,
Washington 6, D. C., April 25, 1956.

Hon. MELVIN PRICE,
Chairman, Research and Development Subcommittee,
Joint Committee on Atomic Energy,
The Capitol, Washington 25, D. C.

MY DEAR MR. CHAIRMAN: I had hoped that it would be possible to testify in person before your subcommittee, but a series of prior commitments prevents my doing so. I shall appreciate it, therefore, if the attached statements can be included in the record of the subcommittee's hearings on the important problem of the shortage of scientists and engineers.

Very truly yours,

JOHN LESTER BUFORD, *President.*

STATEMENT OF JOHN LESTER BUFORD, PRESIDENT, NATIONAL EDUCATION ASSOCIATION

Mr. Chairman and members of the subcommittee, I am John Lester Buford, superintendent of schools in Mount Vernon, Ill., and president of the National Education Association. For the record, the NEA is a voluntary organization of 650,000 dues-paying members of the teaching profession. Affiliated with the NEA are 66 State education associations and 5,542 local education associations.

I. SCIENTISTS AND THE MANPOWER PROBLEM

The shortage of scientists and engineers has been dramatized by reports from visitors to the Soviet Union like former Senator Benton of Connecticut, by the DeWitt study of Soviet professional manpower published by the National Science Foundation, and by the document prepared for this subcommittee by the legislative reference service of the Library of Congress. There can be no doubt that the shortage of scientists and engineers in the United States is serious and that our technical superiority over the Soviet Union is being challenged by the number of engineers and scientists graduating from universities and technical institutes in the Soviet Union. The shortage is not confined to scientists and engineers alone. We do not have enough physicians and dentists to go around; we do not have enough nurses to go around; the shortage of promising managerial talent is severe; finally there is a shortage of elementary and secondary school teachers, but especially elementary teachers at this time, with which those who, like myself, have anything to do with administering public schools, are directly concerned. Indeed, I will go so far as to say that the shortage of elementary and secondary school teachers is one that comes closer to most Americans than any of the other shortages of skilled manpower I have mentioned. Nor do I say this simply because I am a schoolman, for I can reinforce my assertion by the following quotation from the report of the Commission of Human Resources and Advanced Training, entitled "America's Resources of Specialized Talent," published in 1954. On page 121 of the report it says: "The problem of meeting the teacher shortage in the most effective manner possible is of direct concern to every one of the specialized fields. Future scientists, humanists, businessmen, and specialists in every other field will get the quality of instruction which the elementary and secondary schools are able to give them. If a poorer quality of education results from the shortage of qualified teachers and the makeshift efforts to overcome that shortage, the next generation of workers in every specialized field will share the loss."

I should like to suggest to this subcommittee that it consider the scientist and engineer shortage in the context of the general prospective shortage of skilled manpower. We need skilled manpower not simply to combat the Soviet challenge. We need skilled manpower to meet effectively the challenges of our own expanding economy including such far-reaching developments as automation, for example. It is hard to believe that just a few short years ago a distinguished economist from Harvard University was predicting the growth of an intellectual proletariat of unemployed college graduates. A more realistic assessment of the need for skilled manpower is that provided by Prof. Peter Drucker of New York University in the first of a series of four articles published in Harpers Magazine last spring. Professor Drucker says: "Our problem is not the breeding of an 'intellectual proletariat' for whom there will be no jobs, but a greater need for trained and educated man- and woman-power than the country can possibly supply * * * the technological revolution of 'automation,' already underway,

primarily requires a tremendous increase in the number of trained and educated people. And it is already true today that the short supply of such people is the major limiting factor on the rapid growth of our economy and of our principal industries. We need not worry, therefore, about our ability to absorb these millions of college-trained people; we have to worry principally about increasing their number and quality fast enough."

II. SCHOOLS AND THE MANPOWER PROBLEM

Because scientists, engineers, mathematicians, teachers, and skilled professionals of every kind are in practically every instance college trained, we tend to look on the manpower shortage in its general and its special aspects as a primary concern of higher education. Certainly, it is true that we must end the leakage between high school and college of the more than 100,000 young men and women of college ability who graduate each year from our high schools but do not go on to college. The Nation can ill afford such a prodigal waste of talent which, if properly encouraged and developed, would provide us with an additional source not only of scientists and engineers but of other skilled professionals, including teachers.

Let us remember, however, that our colleges and universities must build on the foundation provided by our secondary schools. It is in the high school that we must identify our talented youth and give them the incentives and guidance necessary to direct them to a vocational choice worthy of their talents. It is the inspired and competent high-school teacher of science or mathematics who will, in most cases, influence youth of ability to make a decision to go into those fields where the manpower shortages are most keenly felt. Only in the rarest exceptions, can we reasonably expect the high school with inadequate libraries and laboratories, in which the sciences and mathematics are taught by persons inadequately trained for that purpose and inadequately paid for the job that they do, to develop the talents and skills of a potential scientist or engineer.

Let us remember, too, that of the 24,000 high schools in the United States, half of them enroll fewer than 200 students. Also of significance is the fact that 67 percent of two-thirds of the high schools in the United States are located in rural areas of the United States where the population is under 2,500. The average enrollment in the high schools in these rural areas is 158 students as compared with the average enrollment for all American high schools of 324 students. One more statistic about these rural high schools. The average number of classroom teachers in schools of this sort is 7 and class sizes average about 22 pupils per teacher. By comparison, the national average of classroom teachers per high school is 14 and the average enrollment per classroom teacher is 23 students. (The above figures are derived from Statistics of Public Secondary Day Schools, 1951–52, ch. 5 of the Biennial Survey of Education in the United States, 1950–52.)

Rural high schools in the United States enroll a third of our high-school students, but the average enrollment per high school is half of the average enrollment in all American high schools, and their faculties are half the size of that in the average American high school. The course offerings in a rural high school of this sort must necessarily be limited; very often such a school does not have a full-time science or mathematics teacher. Moreover, a school of this sort is generally not able to maintain a fully equipped laboratory of the kind necessary for up-to-date courses in high-school chemistry and physics. Nor is it reasonable to expect the libraries in small rural high schools to have on hand the periodicals and reference materials in the sciences that are needed to stimulate the interest of talented students in those fields.

Here, then, is one major cause of a shortage of skilled manpower and especially of the shortage of scientific manpower. It is inequality of educational opportunity. Of course, there are some excellent small rural high schools where top-quality instruction is given in science and mathematics. But, as I have pointed out, the smallness of these schools militates against a well-rounded program in science and mathematics. The youngsters who attends high school in an urban center with a population of 2,500 or more stands a much better chance of getting adequate courses in science and mathematics than the youngster in a rural high school. And I remind the subcommittee of the fact that 1 in every 3 high-school students attends a rural high school.

Inequality of competition between the graduates of rural high schools and the graduates of city high schools is probably the major adverse factor in the shortage of scientists. But there are some who hold that even the city high schools

are not doing an adequate job of science teaching. The Legislative Reference Service study issued by the subcommittee quotes a statement on page 31 by the assistant secretary of the American Chemical Society which alleges that the reason our high schools are not doing more toward training scientists and mathematicians is that "problems of major proportions are being created by the great expansion in numbers of students, the tendency to provide high-school education for all with the unavoidable trend toward mediocrity, the high cost of education, the shortage of teachers, the shift of educational emphasis away from traditional academic subjects to vocationalism, and other factors."

This same study on page 82 cites a recommendation by President Retalliata, of the Illinois Institute of Technology, that our high-school programs prescribe courses in English, mathematics, science, and history sufficient to meet the requirements of accredited colleges of engineering or science. President Retalliata says he would also support this with more effective counseling on the advantages of a college education and constructive efforts to increase the number of those who would enter fields of teaching. To these last two suggestions I would cry a hearty "Amen."

Let us take a closer look, however, at the idea of prescribing courses in high schools so as to prepare people for entrance into engineering or scientific studies. On this point I should like to make two observations. The first is that the whole character of secondary education in the United States has changed in the last 50 years. Some would say it has changed for the worse; but most would say it has changed for the better, despite the strains and stresses that are unavoidable in the case of such rapid growth. Our secondary schools enroll more than 7 million pupils now where in 1900 they enrolled some 700,000. In terms of percentages, our secondary schools enroll about 80 percent of those in the high-school-age group; in 1900 they enrolled only 11½ percent of those eligible.

It is true that our high schools offer a more general education than they did in 1900. One reason for this is that high schools no longer concentrate almost exclusively on the college preparatory student. Instead, our high schools try to reach the needs of the 14- to 18-year age group, some of whom want to go to college; others of whom wish to prepare for employment upon leaving high school. The student of college ability is encouraged to take courses that will help him meet college entrance requirements. Other students take courses that will fit them for a competitive employment situation. On the other hand, no rigid lines are drawn, as they used to be, between the academic, the general, the commercial, and the vocational student. I think it is safe to say that the American people do not want their schools used to raise any barriers of social status between one occupation and another.

This feeling is well expressed in one of the recommendations of the newly released report of the Committee for the White House Conference on Education which says: "Just as good schools permit flexibility in this whole Nation by allowing individuals to achieve the level of accomplishment their abilities deserve, the school system must be flexible within itself. Pupils should be able to shift from one program to another as they grow and change in interests and abilities. This committee thinks that for every child to have, throughout his school career, the chance to change to the kind of education found best for him is more important than the time saved by choosing a few pupils early in their lives for accelerated, specialized programs, as is often done in Europe. The American people have time as well as the physical resources to allow this kind of flexibility." (A Report to the President, Committee for the White House Conference on Education, Washington, D. C.: 1956, p. 12.)

Here, I think, is the answer to those who want to solve our shortage of scientists and engineers by prescribed courses and other compulsory methods.

The other observation I wish to make on this point is that I think the American people would resent very deeply any attempt by a congressional committee or by any Federal agency to prescribe what our high schools should teach, or to set as a condition of Federal assistance for schools, requirements as to what courses shall be taught and under what conditions. I hope that if the subcommittee is considering any recommendations as to what the Federal Government should do to help our schools and colleges train more and better scientists that they will avoid any appearance of Federal direction of the high school curriculum. Certainly, the Committee for the White House Conference on Education made it clear at every point that their recommendations were very general in application and were intended to be studied and adapted to local circumstances by the hundreds of boards of education which are primarily responsible for determining what shall be taught in our schools.

III. THE FEDERAL GOVERNMENT AND THE SCIENTIFIC MANPOWER SHORTAGE

Through the work of the National Science Foundation, the Federal Government has made a modest start at easing the scientific manpower shortage through research grants, and more recently, through summer institutes and special training programs for high school science teachers. But these are limited approaches to a complex problem. Let me suggest two broader approaches.

I have called the Subcommittee's attention to the fact that more than 100,000 young men and women graduate each year from our high schools but do not go on to college, although they show evidence of superior ability. Here, then, is one area in which the Federal Government could take appropriate action through a national scholarship program to encourage more young people to go to college. Without going into the details of such a program, I should like to suggest that it be sufficiently comprehensive to make a significant increase in the number of talented students going to college. That is to say, a Federal scholarship program should be conceived of not in terms of a few hundred or a few thousand scholarships, but several thousand scholarships, perhaps as many as 50,000 a year, to be awarded without restrictions as to the field of study. Even then, this would only take care of half of the 100,000 or more who do not go on to college. But there is evidence in studies prepared for the National Science Foundation by the college entrance examination board that financial reasons account for half of the talented who each year do not go on to college.

What action should we take at the level of elementary and secondary education, but especially in secondary education? One of the problems to be faced is the unequal financial competition between the high school science teacher's salary and the salary he could get as a scientist or technician in industry or even in the employment of the Federal Government. One proposed solution to this is that the Federal Government make special grants for paying science teachers just as it now makes special grants for paying the salaries of vocational teachers under the Smith-Hughes and George-Barden Acts. But this would be to treat the symptoms instead of the malady itself. A more basic remedy is to do a more realistic job of financing our public schools than we do now.

As you probably know, the Committee for the White House Conference on Education has declared that in order for the American people to attain the educational objectives they wish for their children, the amount of money spent on education should be approximately doubled within the next decade. Unless we propose to double our real estate taxes which now carry most of the burden of financing public elementary and secondary education, our schools must look for this increase in revenues to State and Federal Government.

Let us make no mistakes about it. If the shortage of scientists and technicians is as serious as the evidence makes it out to be, the Federal Government must take action. The question is, What sort of action? My answer to this is, action that will provide substantial financial support for talented youth who wish to go on to college; and action that will allow the Federal Government to share with the States and localities the cost of constructing the schools we need, of paying teachers salaries more nearly commensurate with their responsibilities and training, and equipping these schools with books and laboratories and other aids necessary for learning. This subcommittee would also do well to consider how the Federal Government through increased financial support of public education can end some of the inequalities of educational opportunity such as now exist in the United States, so that the advantages of a good education, including a good education in the sciences and mathematics, shall not be denied to a young person simply because his community lacks the financial resources necessary to support good schools.

These proposals may seem to lead the subcommittee far afield from its immediate objective, but I think that the subcommittee will find as its investigation proceeds that the shortage of skilled manpower, including scientists and engineers, will not be eased until the American people make up their minds as to how to finance the educational opportunity they want for their children. The association I have the honor to represent has believed for many years that this cannot be done without the help of the Federal Government. I hope, therefore, that the subcommittee will recommend to Congress and to its appropriate standing committees the enactment of legislation that will channel Federal funds to the States and Territories for the support of public education, such funds to be expended without Federal control over State and local school operations.

HARVARD UNIVERSITY,
GRADUATE SCHOOL OF PUBLIC ADMINISTRATION,
DEFENSE STUDIES PROGRAM,
Cambridge, Mass., April 5, 1956.

Subject: Special defense studies report on skilled manpower and national security.

By: Dr. Harry H. Ransom, research associate, Harvard University.

SKILLED MANPOWER AND NATIONAL STRATEGY—THE RACE FOR SUPERIORITY IN A VITAL SECRET WEAPON

(By Dr. Harry H. Ransom, Harvard University)

On a blustery day in late March (1956) a sleek, twin-jet Tupolev–104[1] passenger plane came down through the rain clouds to land at the London airport. Its main cargo was "Ivan the Terrible" Serov, chief of Russia's security services, who had been transported to England in a 3½-hour, 1,564-mile flight from Moscow.[2]

The TU–104 plane excited more attention than the appearance of General Serov, in England to supervise security arrangements for the visit by Khrushchev and Bulganin. Aeroflot's[3] jet airliner was "new evidence of the remarkable advances in aircraft design made by Russia during the last few years," according to a leading American aviation publication.[4] It is powered by two of the largest turbojet engines operating in the world today. Its design is said to be similar to that of the standard Russian medium jet bomber—the Badger.

Some months earlier, in a seemingly unrelated and far less publicized activity, an admiral of the United States Navy made a speech to a conference, sponsored by the Edison Foundation Institute, West Orange, N. J. In this speech, Rear Adm. Frederick R. Furth, chief, Office of Naval Research, warned that Russia had begun to outgain the United States in the training of scientists, engineers, and technicians. He noted a specific symptom of the problem when he said that in the fall of 1955 only 125 new college-trained physics teachers were available for the 28,000 high schools in the United States.[5]

While there is obviously no direct connection between the Soviet achievement of producing the TU–104 jet transport and last fall's shortage in the United States of high school physics teachers, there is, however, a relationship here of crucial importance to the Nation's long-range strategic plans for security.

WINNING THE TECHNOLOGICAL RACE

United States Armed Forces today are engaged in a technological race with the Soviets. The outcome may affect national survival. America's defense policymakers—both civilian and military—now are showing increasing awareness that this race may be won or lost in the field of research and development, and ultimately in the Nation's classrooms. This awareness is evidenced by a considerable amount of publicly expressed alarm, not only about Soviet weapons systems achievements, but also over the long-range implications of an impending United States shortage of high-quality scientific and engineering manpower.

Any projected strategic plan to contain Soviet expansionism or to deter aggressive war by the Communists obviously must be based on a careful calculation of Soviet military potential. And plans to win a war we cannot deter must be the result of the most precise estimates possible of national strategic capabilities.

Students of strategy know that a nation's economic potential is one of the most relevant indicators of strategic capability. Competent analyses of the foundations of national power have always taken into account scientific and technological skills—a basic ingedient of national economic strength and military

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[1] Andrei N. Tupolev is a leading Russian aircraft designer. Tupolev recently wrote in Pravda that his jet airliner has a 2,000-mile range; cruising altitude of 33,000 feet; and cruising speed of 500 miles per hour.

[2] General Serov later returned to Moscow in the TU–104. The trip was completed in 3 hours and 15 minutes, which the United Press reported to be a new record time for the London-to-Moscow hop.

[3] This is Russia's civil airline, which plans to use the TU–104 (said to be in quantity production) on the Moscow-Peking route and routes connecting Moscow with European capitals.

[4] Aviation Week, April 2, 1956, p. 28.

[5] New York Times, November 22, 1955, Soviet Outstrips the United States in Training Scientists.

potential. These skills now must be accorded an even greater importance in estimates of the future strategic capability of a nation.

NEED FOR AN ACTION POLICY

An essential ingredient in an action policy for national survival thus must include the building of an educational framework which will assure the required amount of skilled manpower. The increasing shortage of this essential element of national strength now must be given a very high priority as the Nation begins to implement its strategic plan for the long haul.

The many immediate specific scientific problems involved in the development of complex weapons today tend to obscure the long-range consequences of our increasing skilled manpower disadvantage vis-a-vis the Soviet Union. Current problems with strategic implications include: How to put successfully a man-made satellite in an encircling orbit around the earth; how to develop missiles with intercontinental range and accuracy; how to build atomic reactors to power ships and planes, or economically to heat, air-condition, and light future cities; and how to solve the problem of the Nation's dwindling natural resources.

Our success in these and other projects will constitute an important variable in long-range strategic calculations. The strategic doctrines, composition, size, and missions of our Navy, Army, and Air Force of the future also will be profoundly affected by our achievements in these projects and by other unpredictable technological breakthroughs. Whatever develops, it can be predicted with confidence that the need for well-trained scientists and engineers, both in and outside the military services, will increase constantly.

This resource will become increasingly important as a measure of our own military capability, as well as that of the potential enemy. But the alarming fact is that we are not insuring the supply of this vital human resource in the future.

And the published facts of the growing scientific and engineering capability of the Soviet Union are equally disturbing. Some encouragement may be found, however, in the increasing, if belated, attention now given this problem by United States policymakers.

SOME SIGNIFICANT FACTS

Here are a few of the more significant cold facts, made public in recent months by Government officials:

Universities and technical institutions in Soviet Russia are graduating engineers in numbers some two and a half times greater than are similar institutions in the United States.

The United States is now training only one-half its required number of engineers and scientists.

A recent report of the Congressional Joint Atomic Committee (March 1956) reveals that the combined total of engineers and scientists of the United States and 15 Western European nations is about 1,150,000. The Soviet Union total is 890,000 scientists and engineers, not including the satellites and Red China. The Soviet total exceeds that of the United States, and is more than three-fourths the number available in the free nations of Europe combined with the United States.

Most experts seem to feel that Russian scientists and engineers in most fields cannot be considered inferior to our own.

In the decade 1950–60, the Soviet Union is expected to produce 1,200,000 trained engineers and scientists compared to our 900,000.

Even the combined advantages in this regard which the United States and countries of Western Europe has held is being seriously threatened by the Soviet Union.

Half of our high schools teach no chemistry or physics. And much of the mathematics and science is being taught by teachers untrained in these fields.

The number of qualified science teachers in the United States high schools has fallen off 53 percent in the past 5 years, while high school students have increased by 16 percent.

In 1890, 2 generations ago, 1 in every 5 high school students in the United States studied physics. Today the figure is about 1 in every 22.

In the category of engineers alone, the Soviets have multiplied the numbers tenfold since 1930, when records show they had 41,000 engineers.

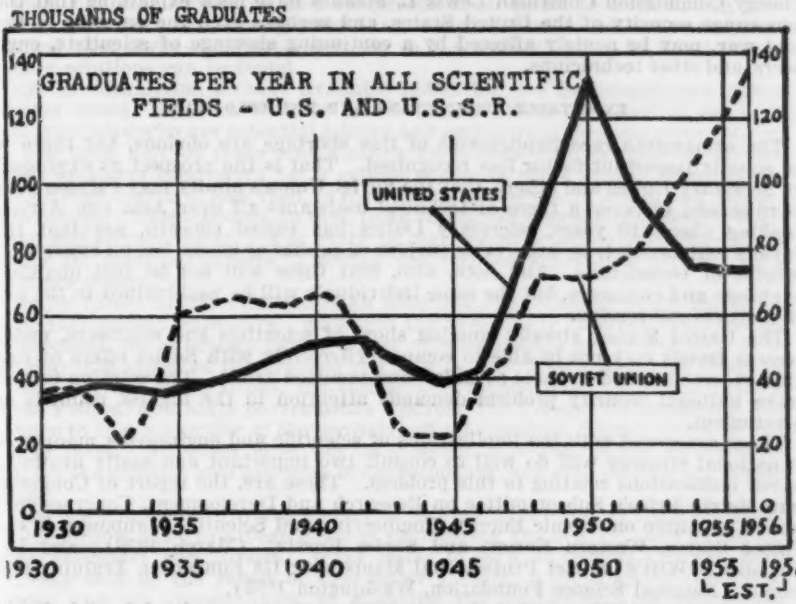
The following chart gives a graphic indication of how United States production of scientists and engineers compares with Soviet Russia. The most disturbing aspect of this picture, of course, is the trend line beyond 1956.

UNITED STATES -- SOVIET RUSSIA

COMPARISON OF COLLEGE GRADUATES PER YEAR,

ALL SCIENTIFIC FIELDS, INCLUDING ENGINEERING

THOUSANDS OF GRADUATES



-- Based on information in study by Benjamin Fine, New York Times, Nov. 7, 1954.

The absolute accuracy of figures on Soviet technical manpower cannot, of course, be assured. Not only do Soviet statistics sometime have a questionable validity, but there is also the problem of measuring quality. One might normally discount the kind of chest-thumping evident at the recent Soviet Twentieth Party Congress in Moscow (February 1956) over their claimed "superiority" in scientific personnel. Premier Nikoli Bulganin referred to technical experts as the Soviet Union's "gold reserve." The current 5-year plan calls for 4 million new specialists by 1960. This would exceed the Soviet combined output of the two previous plans.

Yet obviously we do not have to look to Communist propaganda to discover cause for concern. The words of our own Government officials—both civilian and military—and the unclassified facts, such as these above, are alarming enough.

THE CATFISH AND THE HERRING

The British historian Arnold J. Toynbee tells the story, in the context of discussions of the Free World-Soviet struggle, of the catfish and the herring. It is the tale of the fisherman who continually returned to port with a catch of herring far fresher than that of his colleagues. Thus his fish brought a higher price. Eventually the other fishermen learned the secret. The cagy fisherman always dropped a live and hungry catfish into the tank containing his homebound load of herring. The herring were thus kept active on the voyage to market by attempting to avoid the jaws of the catfish. A few herring were lost en route, but most of them arrived in port alive, fresh and highly marketable.

The Soviet "catfish" has brought critical self-examination to the West in many fields. These include our seapower, the missile program and airpower. None the least of these in long-range importance, however, is the need for more trained scientific and engineering personnel than are now being produced or projected for the future. This has become a crucial national security problem. This need is more often discussed today in terms of development of weapons in the armament race with the Soviet Union. And weapons, of course, constitute an urgent consideration in view of notable Soviet achievements in this field. But this is only one side of the coin.

Recently such officials as Secretary of State John Foster Dulles and Atomic Energy Commission Chairman Lewis L. Strauss have been explaining that the long-range security of the United States, and perhaps even the outcome of the cold war, may be acutely affected by a continuing shortage of scientists, engineers, and other technicians.

EXPORTABLE TECHNICIANS AND THE COLD WAR

The armaments race implications of this shortage are obvious, but there is an equally important factor less recognized. That is the prospect as expressed by Secretary Dulles and others, that the Soviet Union's ability may surpass ours to raise and disperse a force of technical assistants all over Asia and Africa. Looking ahead 10 years, Secretary Dulles has voiced concern, not that the Soviets will have a true, exportable surplus of capital or goods, but an exportable surplus of technicians. And note, also, that these will not be just qualified scientists and engineers, but the same individuals will be well-trained in the art of political subversion.

The United States, already running short of scientists and engineers, under present trends may not be able to compete effectively with Soviet offers of this kind of technical aid to these so-called uncommitted areas. The solution to this grave national security problem demands attention in the highest councils of government.

Those concerned with the implications of scientific and engineering manpower to national strategy will do well to consult two important and easily available recent publications relating to this problem. These are, the report of Congressman Melvin Price's Subcommittee on Research and Development, Congressional Joint Committee on Atomic Energy, Engineering and Scientific Manpower in the United States, Western Europe and Soviet Russia. (March 1956); and Dr. Nicholas DeWitt's[6] Soviet Professional Manpower: Its Education, Training and Supply (National Science Foundation, Washington 1955).

Even in the unlikely event that peace breaks out as a result of feasible East-West disarmament agreements, it should be added that the need for more scientists and engineers would then possibly be greater even than in the present partial-war economy.

"STOCKPILING" A VITAL HUMAN RESOURCE

The Soviet "catfish" is incentive enough, nonetheless, to justify a program of "stockpiling" scientists and engineers with at least the same degree of national urgency, and with the same generosity of funds, brought to bear in recent years on "stockpiling" critical war materials. The precious human resources needed to fill future national security needs cannot, of course, be ersatz or jerry-built.

The future security of the nations of the free world will depend to a certain extent upon their educational equipment for engineering and scientific training. This, in turn, depends upon the number and quality of educational institutions, their teaching staffs, curriculum, and student enrollment, and their financial support. These are the vital "secret weapons" for which those responsible for national strategy must develop an urgent action policy.

TOWARDS A SOLUTION

An action program, although urgently needed, must be based on the most careful examination and diagnosis of the causes of the present and impending shortages of skilled manpower. No crash program can magically produce the numbers and quality of trained personnel needed for the Nations' future prosperity and military security. These can be produced only as the result of carefully prepared plans for readjustment of our total educational system. But such an alteration must come only after a collection and full analysis of all

[6] Russian Research Center, Harvard University.

relevant information. This can best be done by a Presidential commission or a congressional committee.[7]

There is a mass of information now available, however, which offers clues toward a solution to the problem. It is well known that millions of American youth have been denied adequate educational opportunities. Millions of words have been written, and hundreds of pages of testimony taken, about the urgent need for more school teachers, more school construction, and improved curricula. Because of complex political, social and economic factors, however, these needs are being met only with agonizing slowness. The matrix of federalism, intergovernmental competition for the tax dollar, unhealthy condition of many State and local financial structures, and disagreement on solutions both among professional educators and among politicians, seem at first to be insurmountable obstacles. Yet these significant elements in the problem must be faced before adequate solutions can be found.

There is information already available indicating one important area where weakness exists. It is known that in the United States only half of the high school graduates who are potential science and engineering students enter college. And less than half of these who embark on science and engineering studies actually complete their work for a college degree in these fields. There is obviously a high degree of loss, then, in high school, between high school and college, and in college. This amounts, in fact, to an 80 percent wastage of potential engineering and science talent, for of every 10 high school students with theoretical capacity for potential careers in science and engineering, only 2 actually earn the college degree.[8]

A major factor in this attrition is an economic one. College education is becoming increasingly expensive. Although the availability of scholarship money has increased, the education buying power of scholarships has decreased. It is clear that this aspect of the problem can only be solved with increased financial aid from private corporations, the educational foundations, individual donors, and the Federal and State governments. Surely, the Federal Government's role will have to be a major one in the provision of scholarships, teacher training and physical plant. Attention must not be directed, however, at the college-level alone, for the problem also has roots in the secondary, and even elementary, school systems.

There is a long and disturbing history of decreasing interest at the high school level in subjects basic to college study of engineering and science, such as mathematics, chemistry and physics. What seems to be a decreasing interest, however, may only be the result of two major factors; a shortage of competent teachers and an overemphasis, in planning the curriculum, on generalized education.

For many complex reasons the number of college-trained scientists and engineers also is steadily declining. Graduates in engineering and science who received degrees with the class of 1950 comprised nearly 25 percent of the entire class. In 1954, these represented about 18 percent. According to predictions, those of the class of 1960 will comprise a bare 15 percent of the total number of college graduates.[9]

REPAIRING THE EDUCATIONAL FABRIC

It is abundantly clear that the total fabric of our educational system needs repair. It is somewhat surprising that in an age of technology this nation, whose technology surpasses all, should find itself facing serious shortages in such a vital resource as skilled manpower. This argument, parenthetically, should not be taken as one for de-emphasizing liberal arts education, particularly the social sciences. To the contrary, it should be noted that the increasing complexity of our technological society demands extra attention by social scientists. This developing "cold war of the classroom" obviously cannot be won without effective action on the basic ingredients of victory: students, teachers, the curriculum, adequate finance and educational facilities.

It is all too clear that our chief competitor, Soviet Russia, has long since faced this problem with a dogged determination not to be caught short in these vital

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[7] On March 28, 1956, Representative Melvin Price (Democrat, Illinois) stated that his Subcommittee on Research and Development, Congressional Joint Atomic Energy Committee, plans public hearings on this problem. And since this paper was first drafted President Eisenhower has appointed a National Committee for the Development of Scientists and Engineers to survey the problem. See New York Times, April 4, 1956, p. 13.

[8] Engineering and Scientific Manpower, pp. 33–34.

[9] Engineering and Scientific Manpower in the United States, Western Europe and Soviet Russia, p. 33.

resources. Russian technological achievements—such as that TU–104 which landed in London last March—are an indirect result of an intensive kindergarten to graduate school program over the past several decades to assure an adequate supply of scientists and technicians. If they surpass us in this human resource, they have gained a crucial long-range advantage in a primary element of military and industrial strength.

THREAT COMPARABLE TO HYDROGEN BOMB

We may take some comfort in the faith that our spirit of academic freedom, which does not exist in Russia, is a built-in guarantee of superior quality. But this gives us no excuse for complaceny. For Russia's classrooms, laboratories, and ambitious and currently effective plans for mass education pose a threat to our future security comparable to her hydrogen bomb and delivery system.

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STATEMENT OF POLICY BY THE AMERICAN CHEMICAL SOCIETY ON MATTERS RELATING TO EDUCATION

The United States can be proud of its educational heritage. In accordance with democratic principles, it has placed educational opportunities before all its citizens, a situation that exists in few other countries of the world. Paradoxically, this sound basic philosophy and the general availability of facilities are not meeting the educational requirements of our Nation.

Our great country was founded by people who believe in freedom. Many others who shared those beliefs have been drawn to our shores. Freedom of thought and the development of mental skills to their limits were traits of our forefathers. Yet, as the privilege of formal education has been extended to an increasing number of people, appreciation of the value of and need for a disciplined and rigorous education has decreased. Many who now crowd our schoolrooms are capable of absorbing better training. They do not do so because of lack of motivation or lack of opportunities. Parents and teachers alike are at fault if they do not vigorously and enthusiastically urge every pupil to develop his mental growth to the utmost. Roadblocks to educational opportunities must be eliminated.

In the past several years, there has been a sharp decline in the number of scientists and engineers graduating from our colleges and universities. The decline has been more rapid than the drop off in the size of college graduating classes. Also, it has come at a time when demand for persons so educated to meet the needs of national defense and an expanding civilian economy greatly exceeds past requirements and promises to rise still higher. The situation imperils the prosperity and security of the United States because both depend on unceasing advances in science and technology.

Although many factors have combined to cause the drop in science and engineering enrollments in colleges and universities, it is generally agreed that one of considerable importance is the current status of science instruction in the secondary schools. Recent surveys have revealed the following disturbing facts:

1. There is a nationwide shortage of qualified high-school science teachers.
2. The proportion of new teachers of science has been declining more rapidly than in other fields of specialization.
3. Only about 1 student in 11 enrolled in high school elects chemistry, approximately 1 in 16 elects physics, and the proportion who elect various mathematics courses has been on a decline for nearly a half century. About 1 student in 3 who graduate has taken a course in chemistry.

When high-school science, including mathematics, receives so little attention, relatively speaking, it is scarcely surprising that the number of students who major in science and engineering has fallen off. If continued, this trend could have serious consequences to our Nation. Entirely apart from the shortages of specialists whose skills are needed, the situation is unfortunate for high-school students in general. All are destined to live in a world dominated, in peace or war, by the impact of scientific and technological progress. If they are to enjoy useful and satisfying lives in such a world, they must have some understanding of the goals, methods, and importance of chemistry and other basic sciences. If they wish to help mold their own futures, they must have an appreciation of these disciplines. Indeed, such an acquaintance with science is an essential mark of culture in our times.

From a national viewpoint it is eminently desirable that the voters of tomorrow possess some understanding of science. In a democracy the ultimate power

rests with the people and they can use it wisely only to the extent that they comprehend the great issues confronting them. Many of these issues inevitably will be created by the march of science and technology.

Assuring chemistry and her sister sciences of proper recognition is but one of many problems facing our high schools. The shortage of qualified teachers afflicts many disciplines. Construction programs have not kept up with soaring school populations. The school-tax rate in many districts is imposing a burden on its citizens. Any attempt to improve the position of science and mathematics in the high school is likely to fail unless it be a part of a broad effort to strengthen education as a whole.

Therefore, in the interest of the immediate and long-range needs of our Nation, it is the opinion of the board of directors of the American Chemical Society that every step feasible should be taken.

1. To provide increased educational opportunities for all, particularly those known to have unusual ability.

2. To encourage precollege training which will provide a sound educational foundation for higher education in all fields.

3. To assure maximum and uninterrupted growth of scientific developments by promoting a strong educational system at all levels which will provide an adequate flow of qualified, specialized personnel.

The board is of the opinion that these broad objectives are not being met with the vigor they deserve.

Therefore, it recommends that

a. The American Chemical Society strive for the improvement of our educational system as a whole through the efforts of its

(1) Members who should assume personal responsibility for keeping informed of the current status of problems relating to education and as citizens and professional people they should do all they can to improve situations in their own communities,

(2) Local sections which should continue effective and useful projects and expand their programs to include such activities as vocational counseling, teacher and student aids, awards, continuation courses, lecture series, improved science instruction, and other projects especially appropriate for local sponsorship.

(3) Divisions which should continue, and wherever possible expand, those projects which are now being carried out such as improvement of instruction and the sponsorship of publications, tests, awards, conferences, institutes, and meetings related to eduation, and

(4) Staff which should accelerate its activities such as coordinating the programs of various society units, encouraging the cooperation of other interested organizations, publicizing educational matters, and studying problems of special importance to the profession.

(*b*) Elementary schools increase their efforts to provide the important initial training in science and mathematics needed as a foundation for secondary-school education and for understanding of the technological age in which we live.

(*c*) Secondary schools increase their efforts to provide sound college preparation and that those advising students capable of higher education vigorously urge them to pursue the college entrance curriculum.

(*d*) Secondary schools increase their efforts to provide sound science and mathematics courses for those who are not preparing for a higher education.

(*e*) Colleges and universities increase their efforts to provide an adequate flow of qualified graduates in science and engineering to supply the needs for uninterrupted growth of technological development.

The board realizes that the responsibility for carrying out these recommendations is as broad as the Nation and that the American Chemical Society is only one of many organizations interested in the educational problems of our country. It is confident that it has the support of its entire membership in pledging the cooperation with the Federal Government, State, and local governments, school systems, individuals, and organizations whose aims are consistent with those of the American Chemical Society. It hopes that all with an interest in solving these critical problems will take active steps toward rectifying current shortcomings and meeting future needs.

Representative PRICE. The committee will stand adjourned subject to call of the Chair.

(Whereupon, at 3 p. m., the committee was recessed subject to call.)

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